THE ENGINEER

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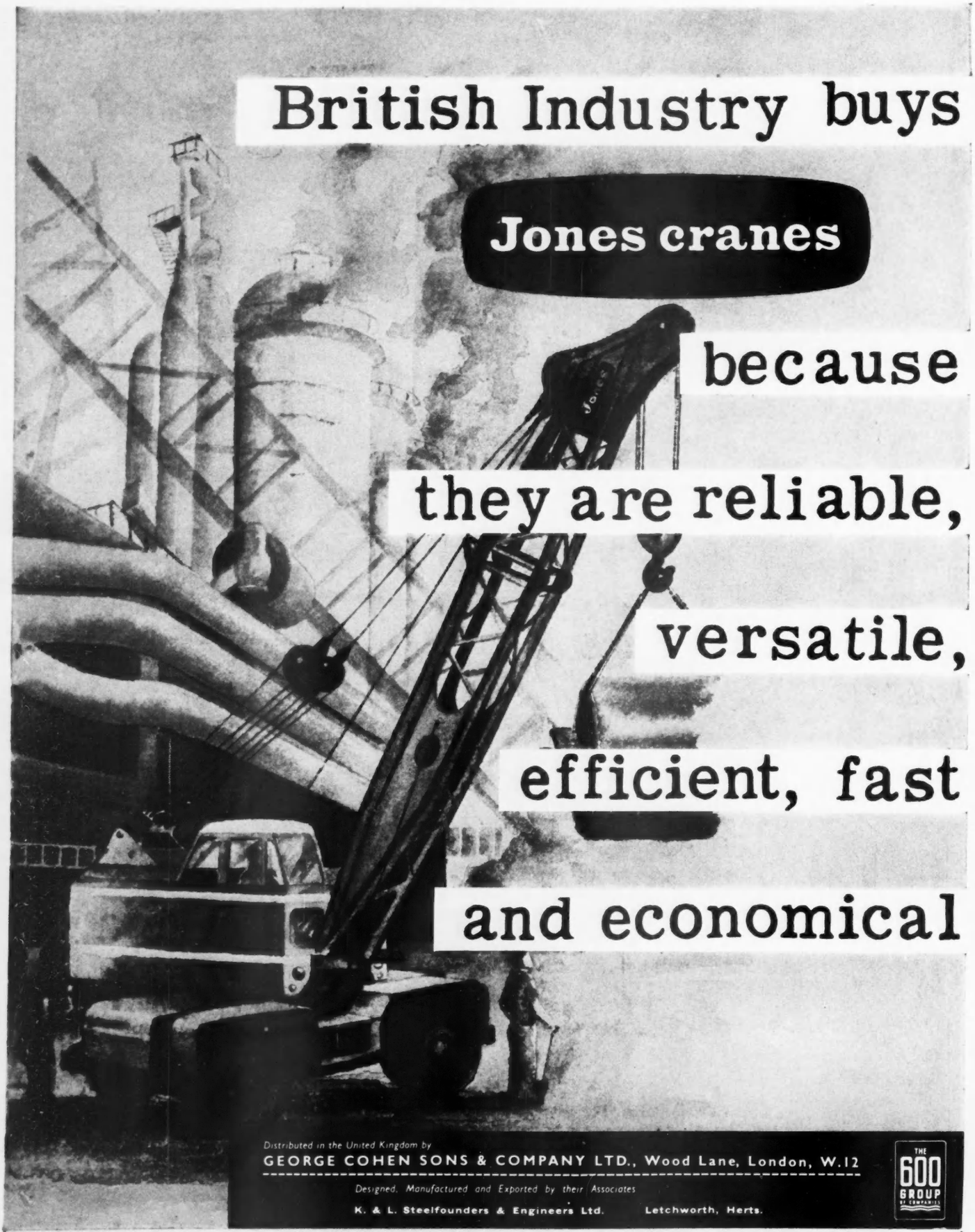
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No. 5421 **DECEMBER 18, 1959** VOL. 208

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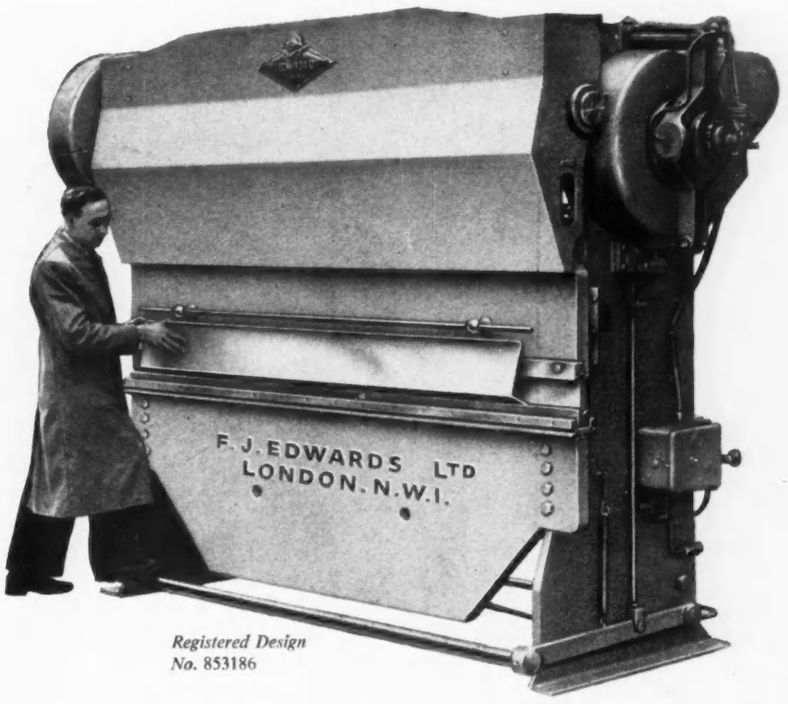

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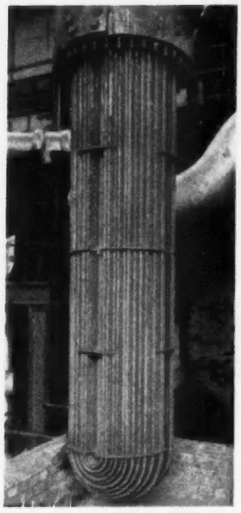

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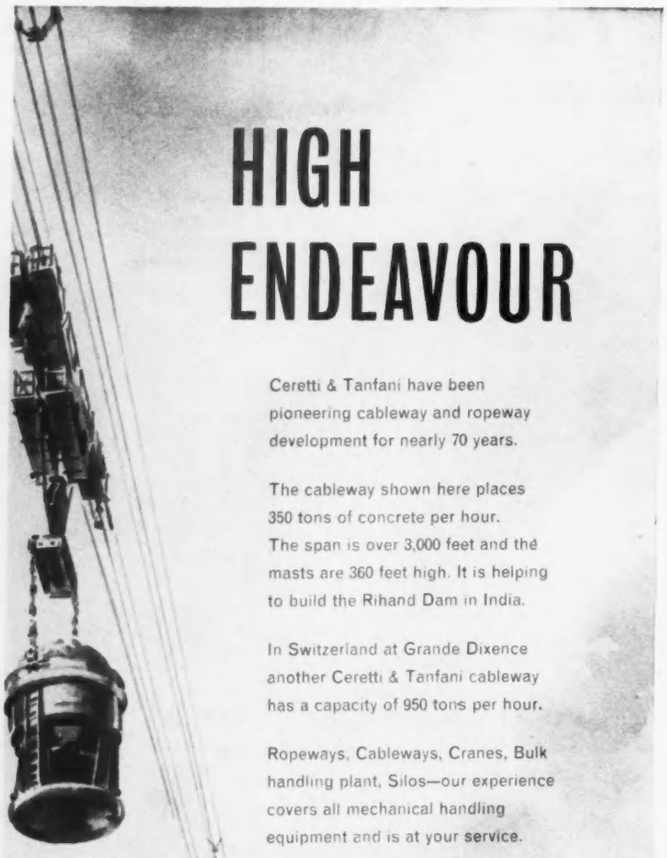

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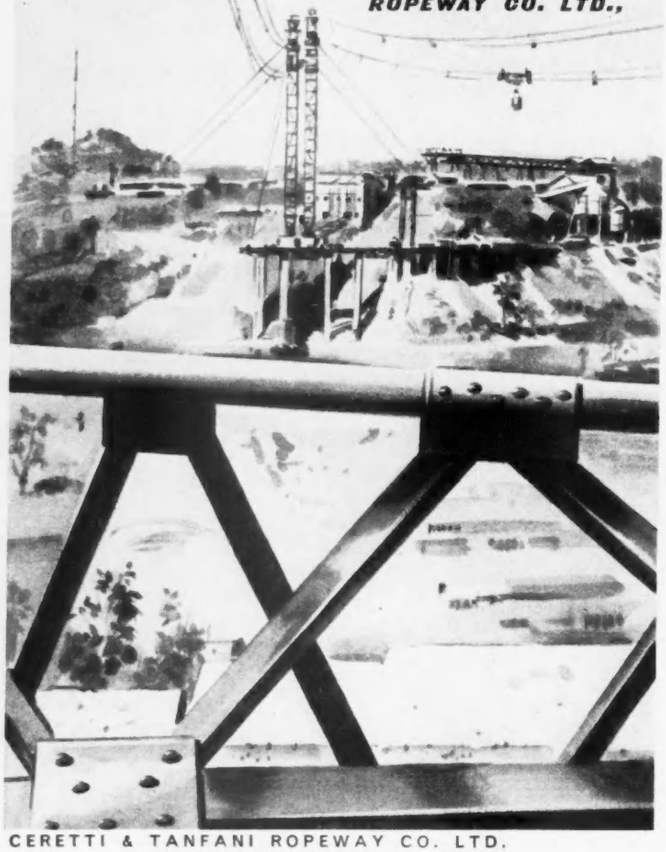

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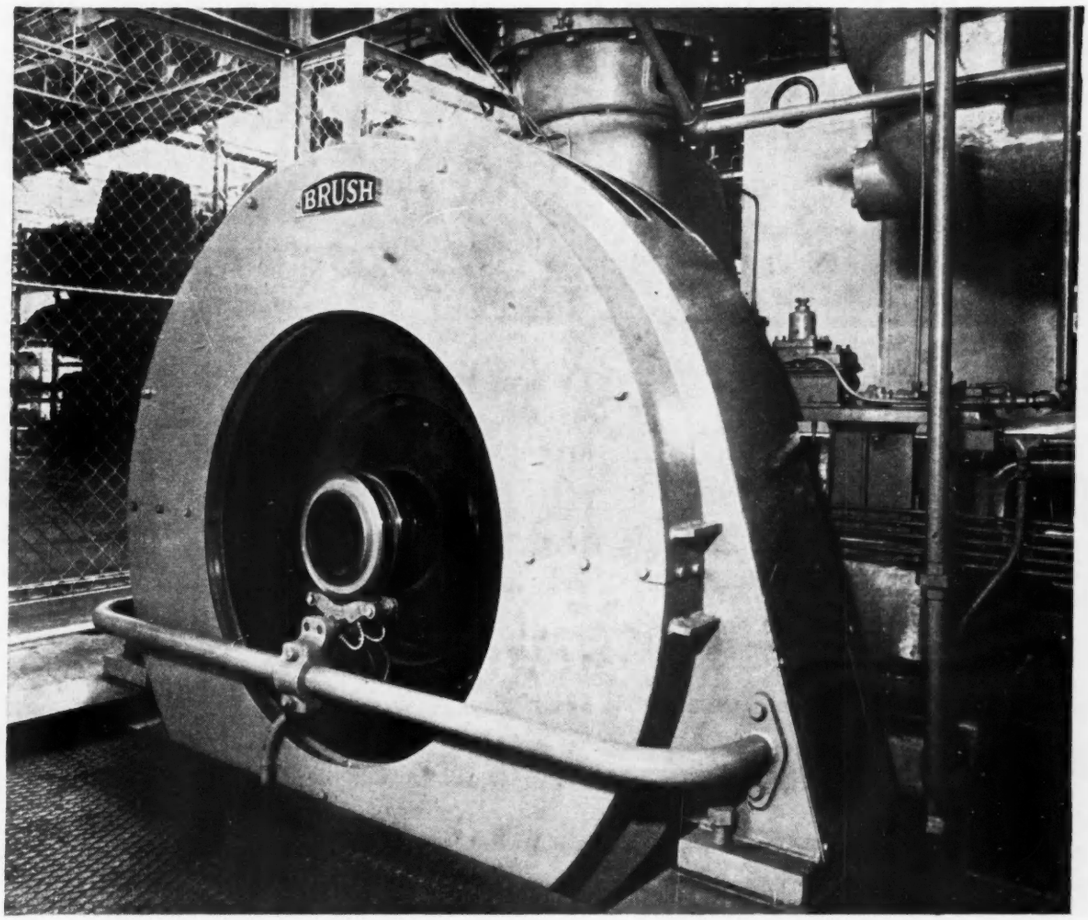

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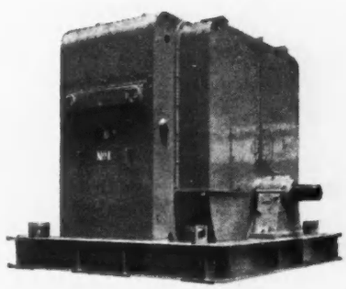

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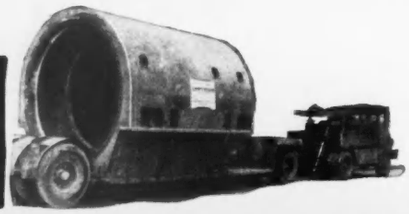

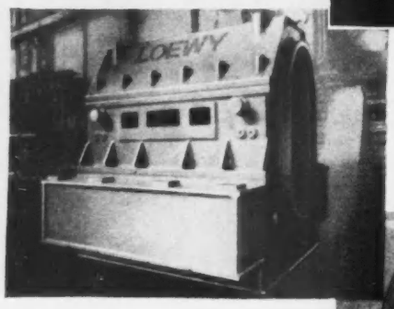

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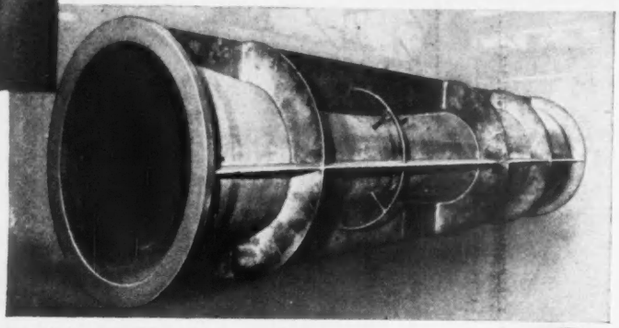

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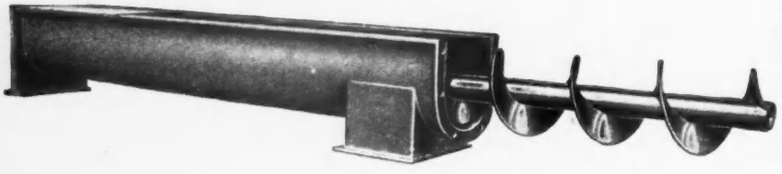

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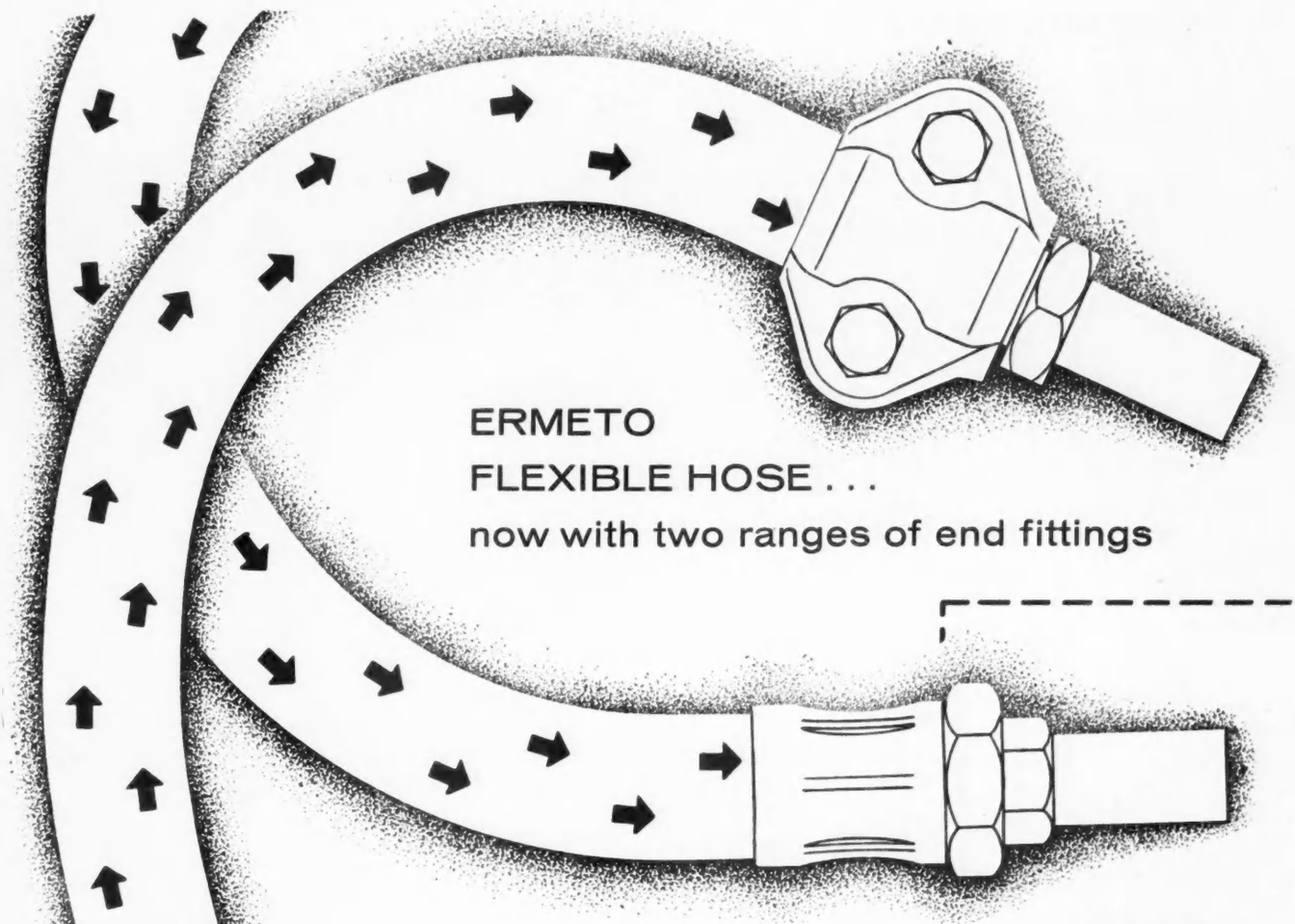

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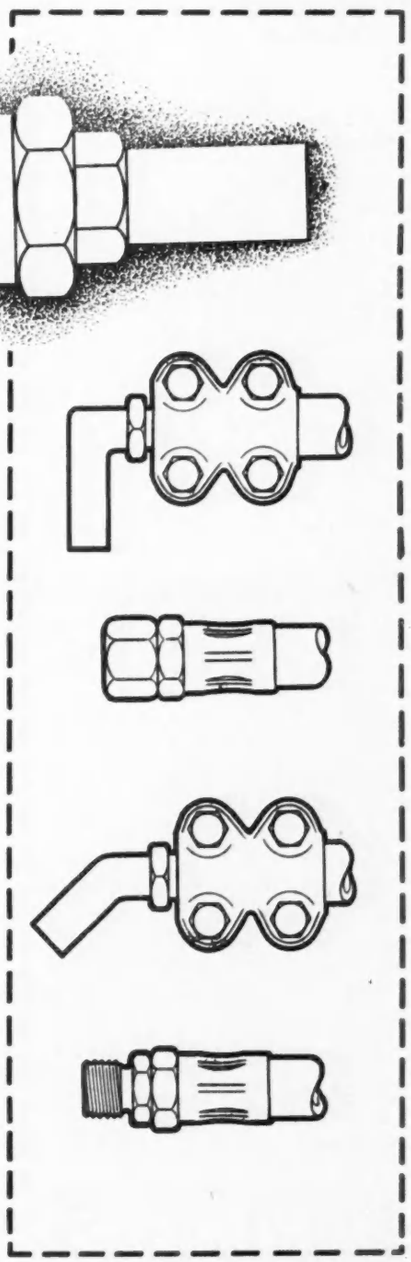

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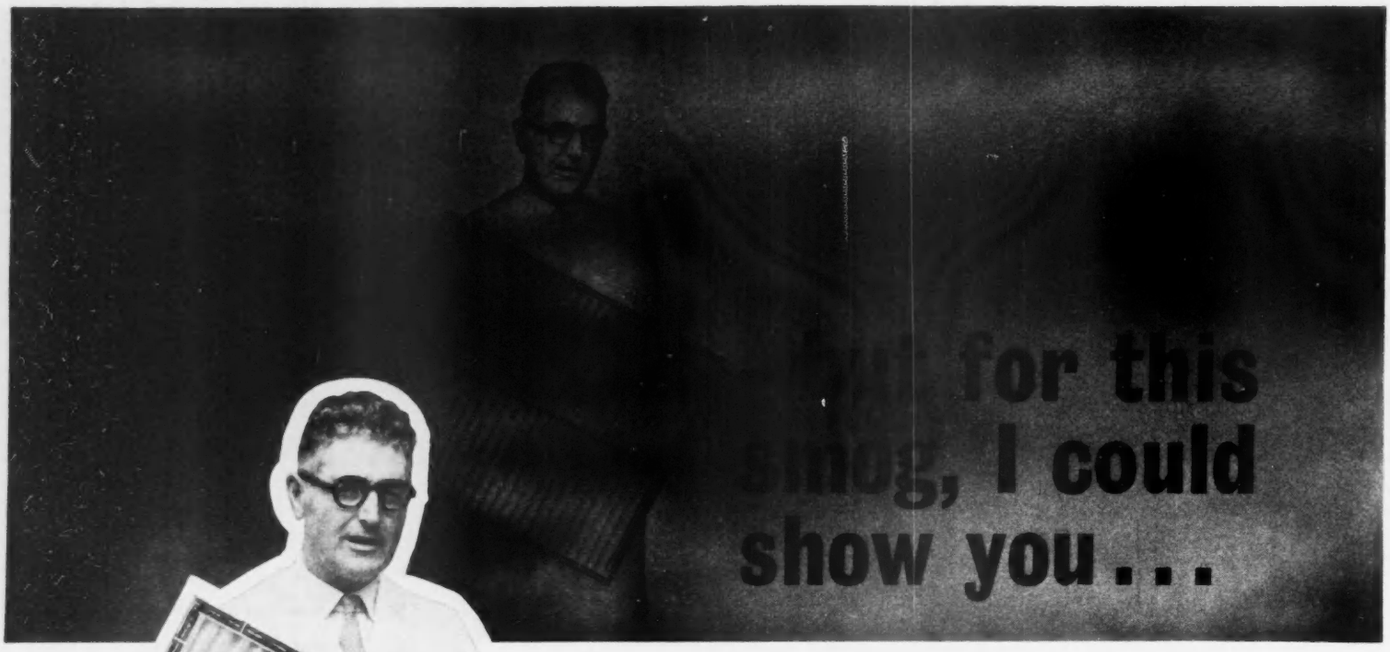

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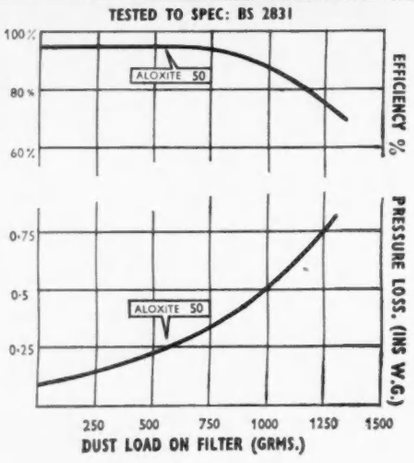

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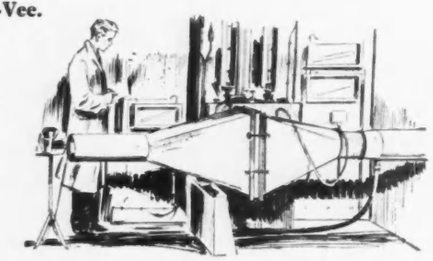

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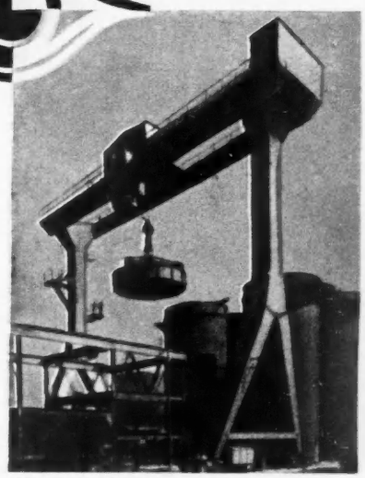

(Above). 50 ton Babcock 'Goliath' crane, of new welded box-girder design, in operation at the Coatbridge Gas Works of The Scottish Gas Board (Main Contractors, Newton Chambers & Co. Ltd.).

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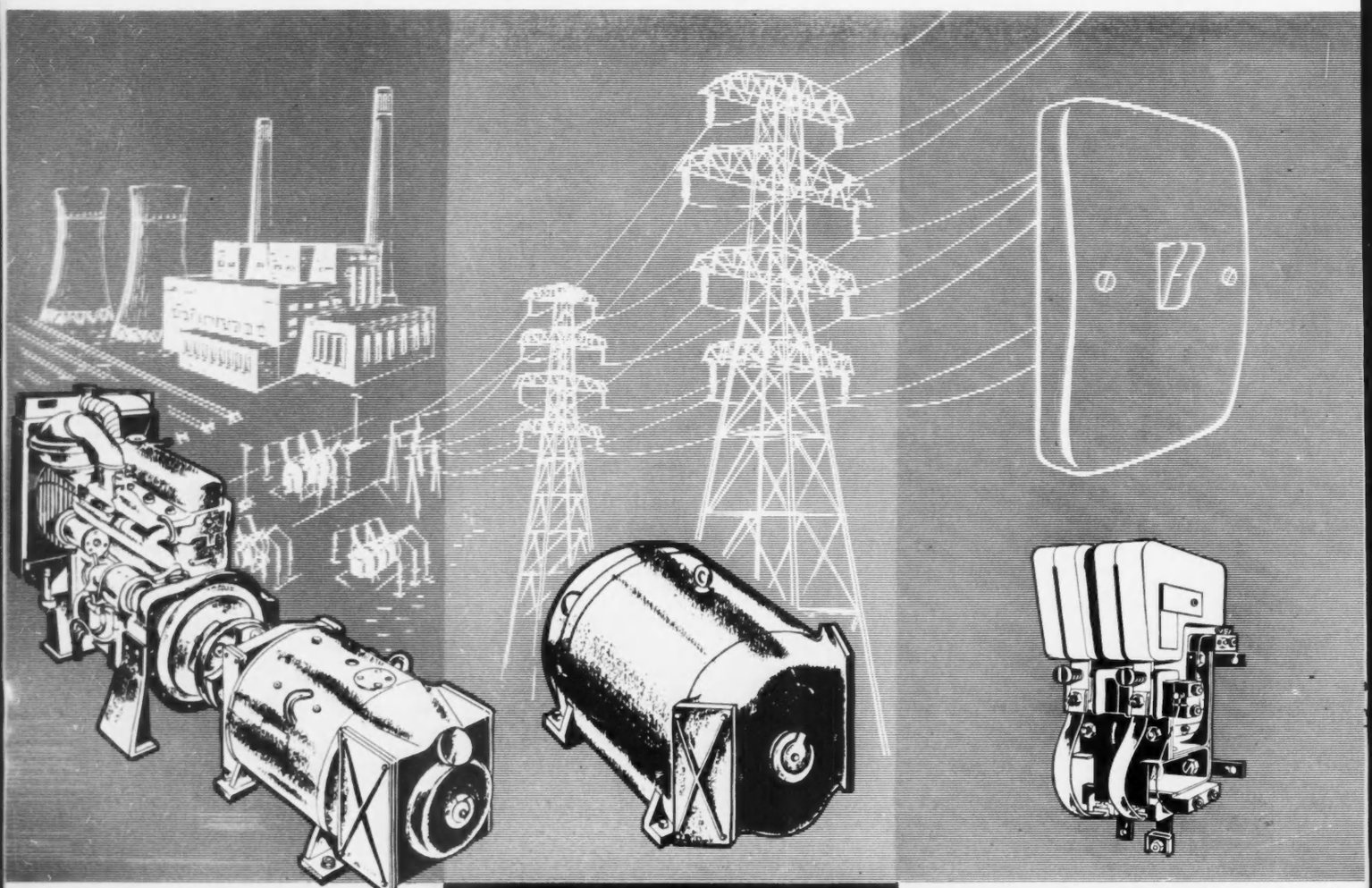

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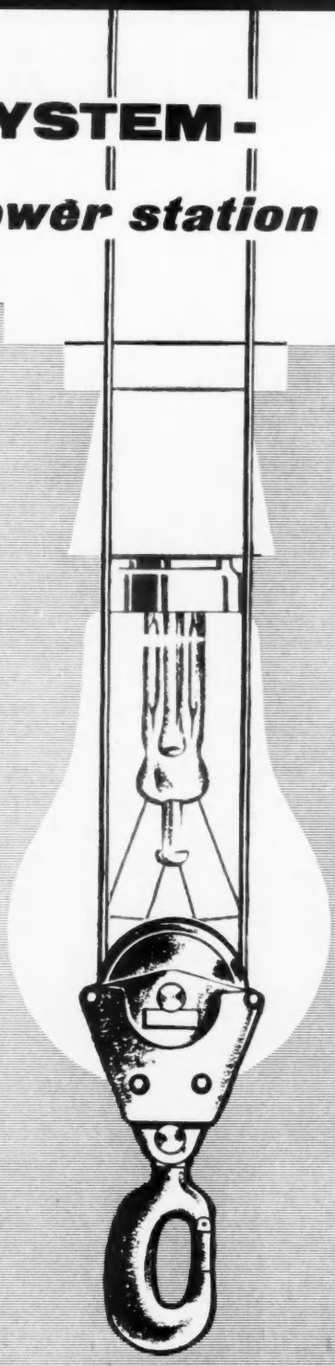

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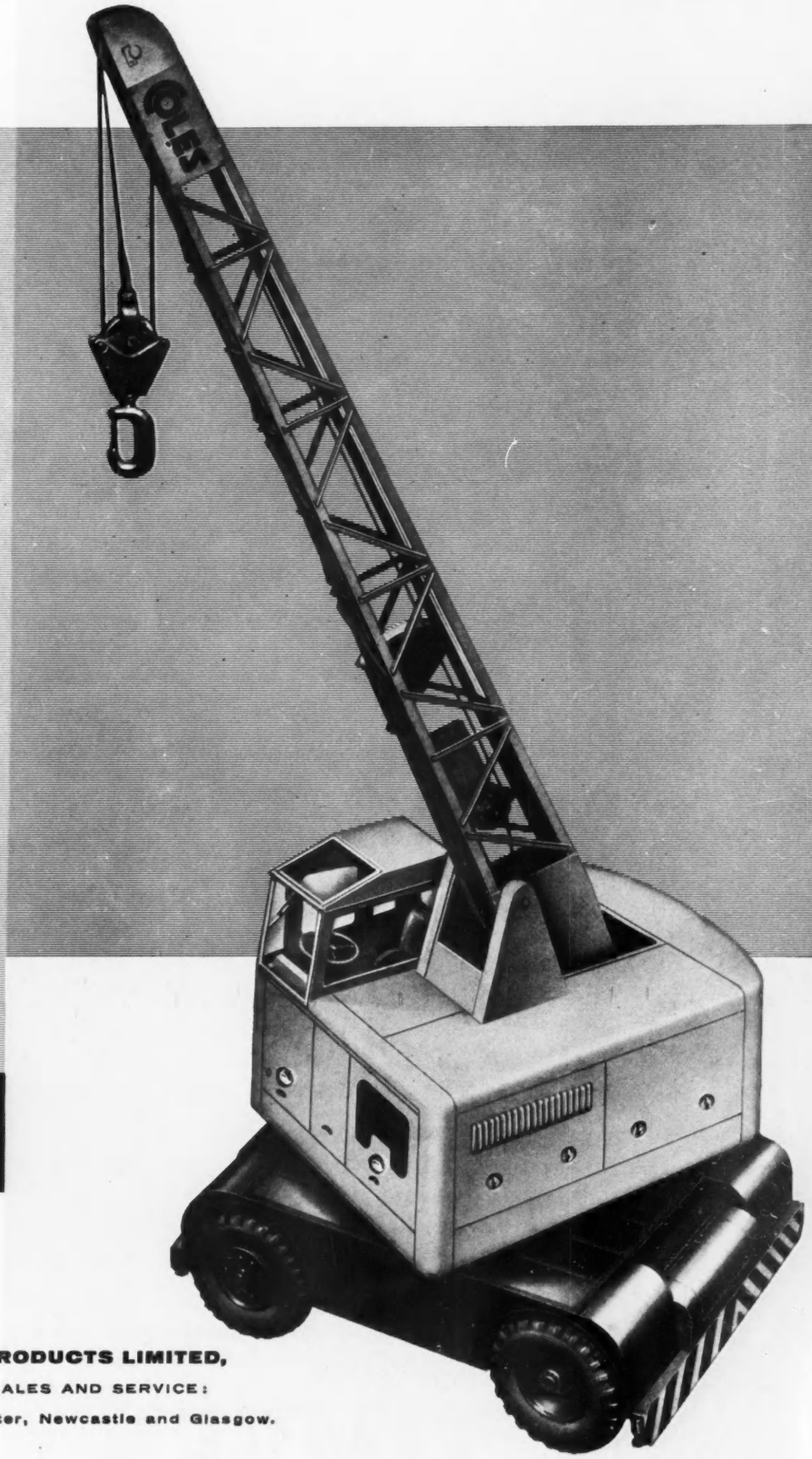

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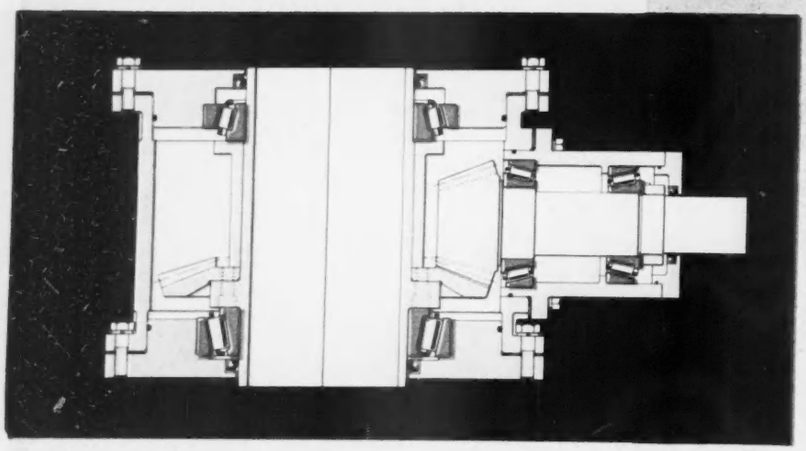

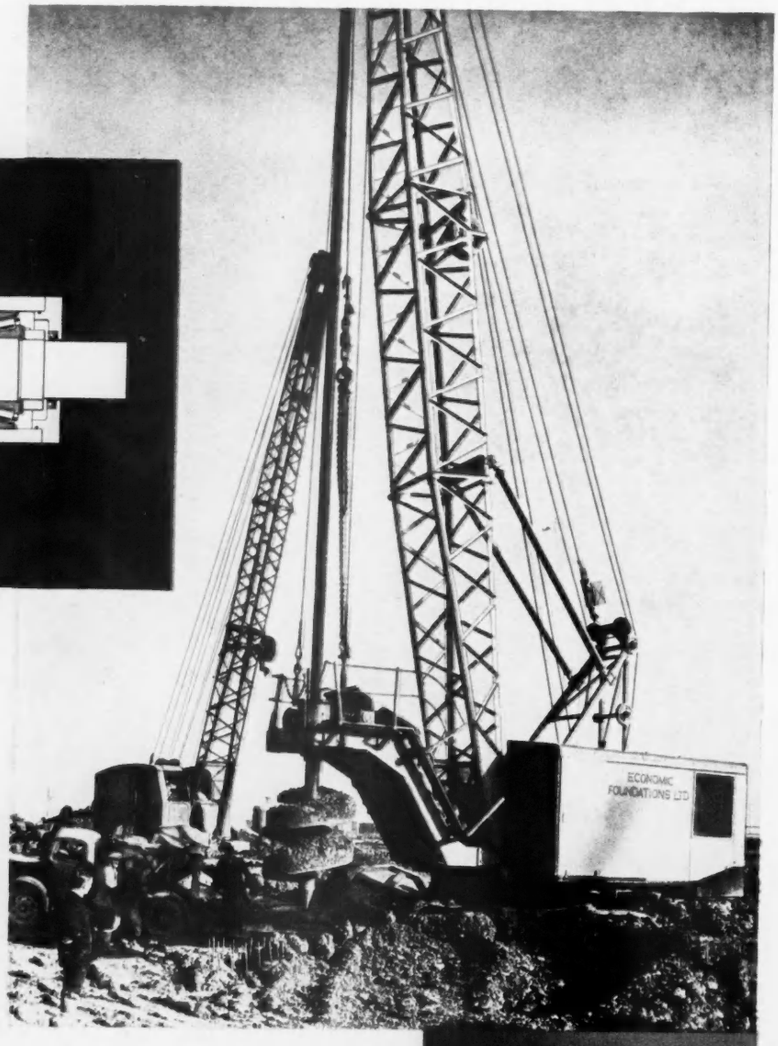

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AUGER MADE BY
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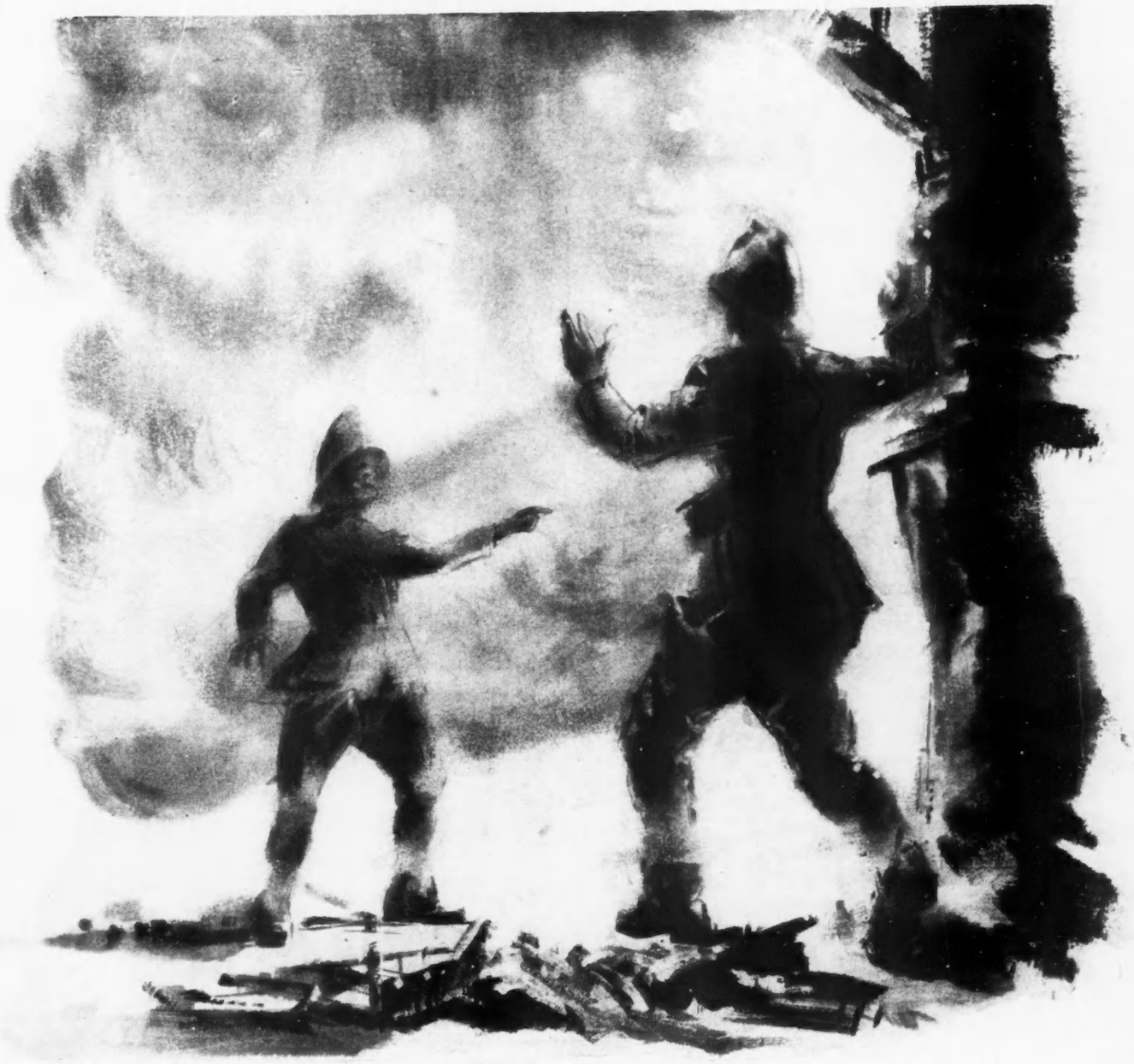

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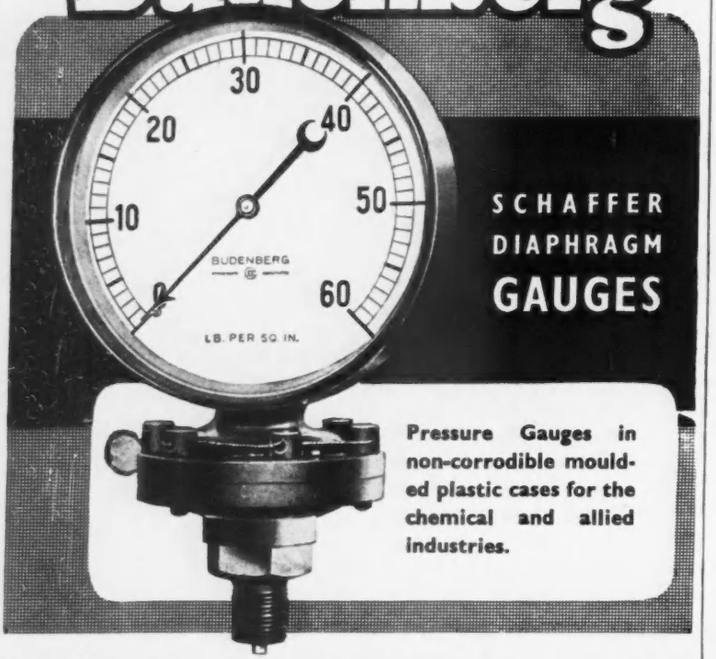

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for the

CENTRAL ELECTRICITY GENERATING BOARD

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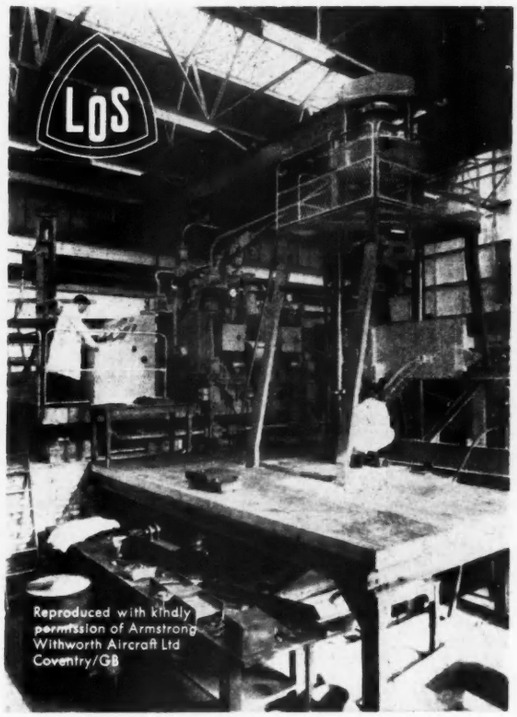

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HERE are brief notes of guaranteed jobs carried out on the spot by the Barimar "Flying Squad" Repair Shops. They tell of resource, rapidity and saving time and money.

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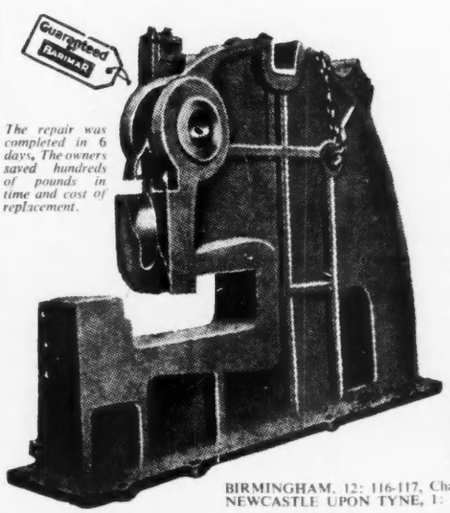
The Contractors were under a "time penalty" if this giant oven was not operating in time. Barimar "Flying Squad" saved the day, welding hundreds of feet of seam in inner casting, with 800 rivet heads and several cast iron plates welded to steel casing. A rush job but perfect to the last rivet.



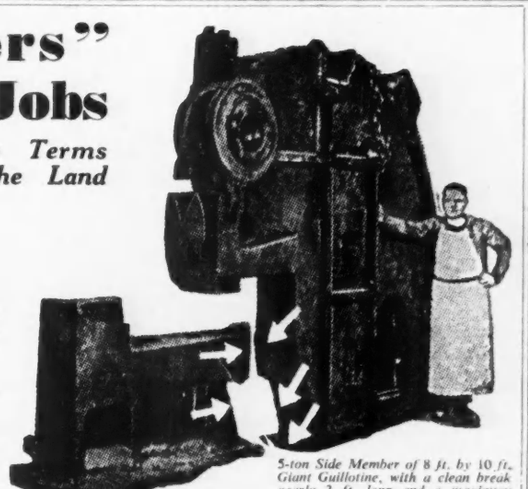
The repair was completed in 6 days. The owners saved hundreds of pounds in time and cost of replacement.

Sailed as Scheduled . . .
A South American cargo steamer in Surrey Docks, held up by a fractured stuffing-box in the marine engine, avoided heavy dock dues and penalties by calling a Barimar "Flying Squad" which completed a guaranteed repair in record time.

Giant Stone Crusher at Mountain Top restored to Service . . .
The largest Granite Crusher in Great Britain had broken down. It was at the top of a 1500 ft. mountain in North Wales. Work came to a standstill so Barimar was sent for. Barimar guaranteed to repair and strengthen the side member *in situ*. A "Flying Squad" of Barimar Welders left immediately. Working practically day and night the job was finished within the contract time of six weeks. Then the Crusher resumed work—24 hours a day, to catch up arrears. Truly a magnificent test for this Barimar Record Repair.

Five Days versus Three Months . . .
The main journal of a 30-ton crankshaft 12 in. diameter was broken. A new one was impossible under three months. A Barimar "Flying Squad" hurried to the North of England, making a perfect repair in five days.

Breakdown Sunday—Ready Monday
Without dismantling the engine of one of Britain's largest tractors, a Barimar "Flying Squad" in Essex repaired a sump under difficult conditions, welding the drawbar lug at the same time. Repaired on Sunday the tractor was at work next morning.



5-ton Side Member of 8 ft. by 10 ft. Giant Guillotine, with a clean break nearly 3 ft. long and a maximum thickness of 8 in. by 9 in.

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The 15-ton head of a 1000-ton hydraulic press (producing electric cable) split completely in half, holding up contracts threatening a loss of thousands of pounds. A Barimar "Flying Squad" worked day and night till the job was finished, leaving the damaged part 25 per cent stronger than new. Press has since been working splendidly.

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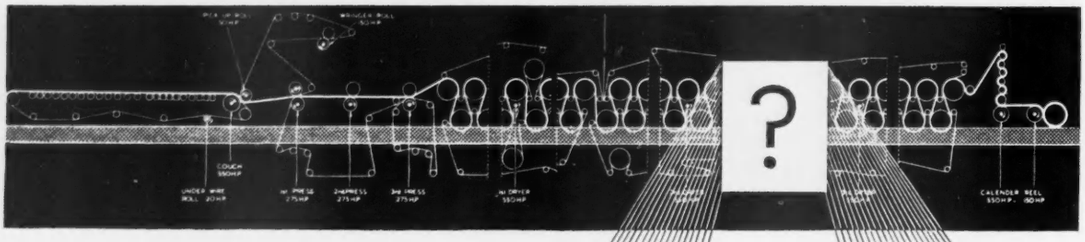

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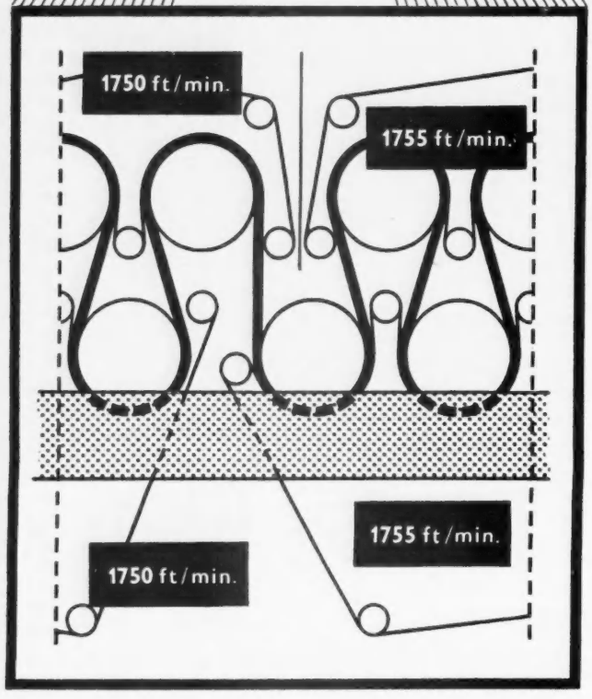

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who specialises in your industry. He understands your particular problems and will ensure that you get drives and control gear designed to meet your exact needs. But his services go far beyond the supply of equipment. He will assist with every aspect of the problem, including layout, integration of related equipment, safety and operational considerations.

AEI **Associated Electrical Industries Limited**
Motor and Control Gear Division
RUGBY & MANCHESTER, ENGLAND

INCORPORATING THE MOTOR AND CONTROL GEAR INTERESTS OF BTH AND M-V

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MONARC
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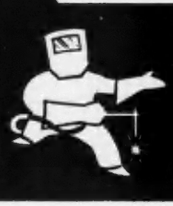
The range of ACTARC equipment includes: general and special-purpose electrodes; air-cooled and oil-cooled welding transformers; rectifiers, plant and accessories.



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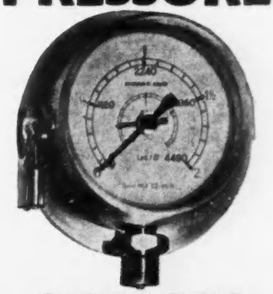
To gauge your requirements

PRESSURE



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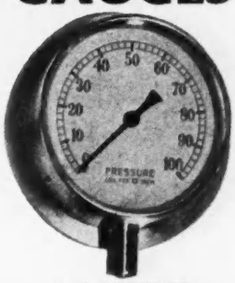

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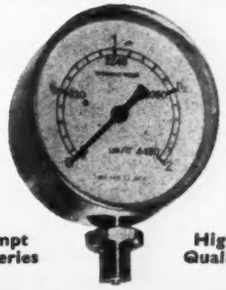

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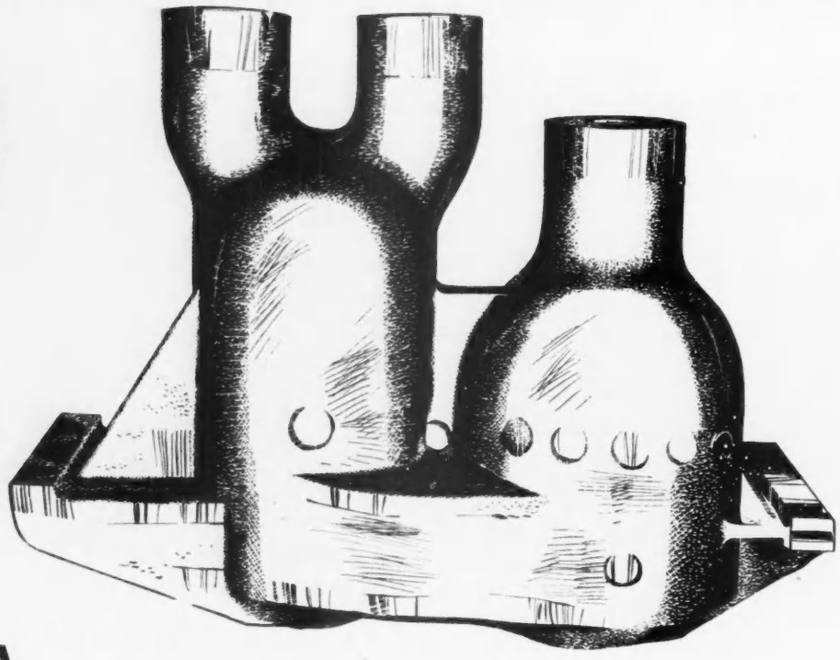
for internal pressure work



Turbine Casings, Steam Chests, Valves, etc., in carbon and alloy steels up to 15 tons weight and to any specification.
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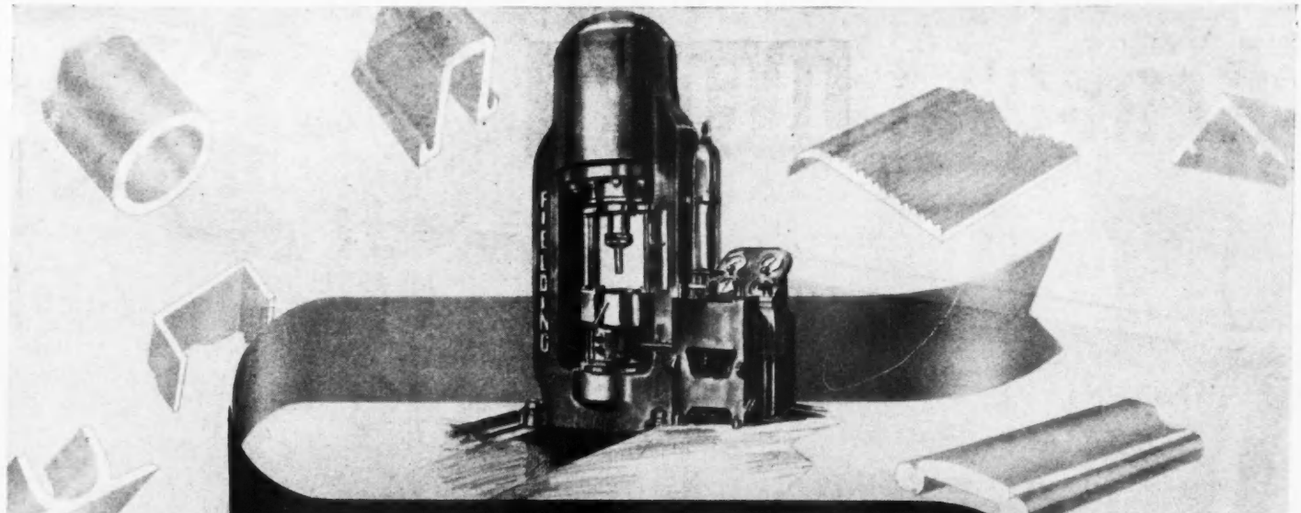

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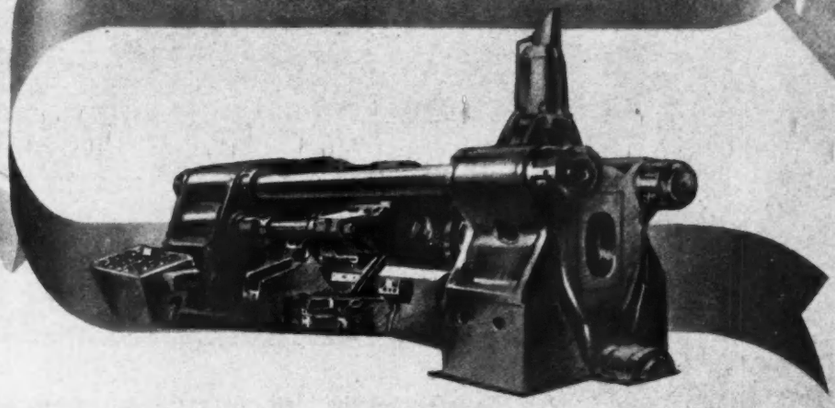

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'HARCO' at ILFORD

To safeguard the high quality of their photographic products, Ilford Limited take every precaution to exclude dust from manufacturing departments. Employees change into nylon overalls leaving their outer garments in

'HARCO' CLOTHES LOCKERS

These are of open wire mesh on stout steel frames, providing security for personal property whilst allowing filtered air to circulate freely through the clothes.
Also available in sheet steel, 'Harco' Lockers are a valuable amenity and encourage tidiness. Made in various sizes; easy to install; strong and durable. Please ask for List No. 1009

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The Anatomy of Newman Quality—6

NEW FEATURES

allied to proved principles

BRAKE DESIGN

This picture shows a flange mounting drip-proof motor, fitted with the disc brake. However, any Newman motor (drip-proof or totally enclosed) from f.h.p.–40 h.p., foot, flange or face mounting can be equipped with the brake. See over for more details.

Newman

Making the pace in motor progress

'HARCO' at ILFORD

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These are of open wire mesh on stout steel frames, providing security for personal property whilst allowing filtered air to circulate freely through the clothes.
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Newman

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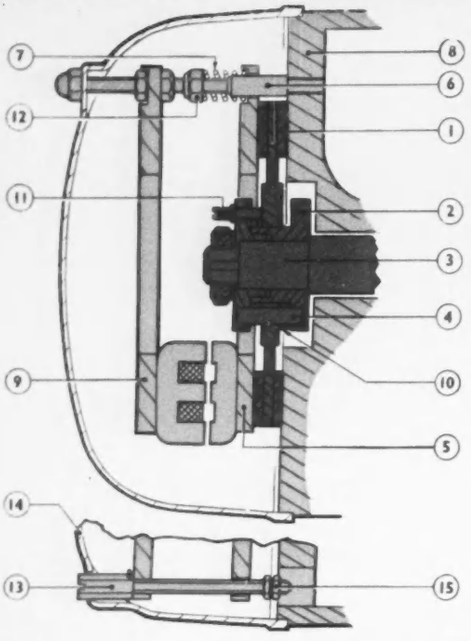
Newman BRAKE DESIGN



■ Rotating parts of brake ▒ Stationary parts of brake

This diagram shows a single disc brake mechanism. Double disc brakes are used for higher torque values but construction is similar.

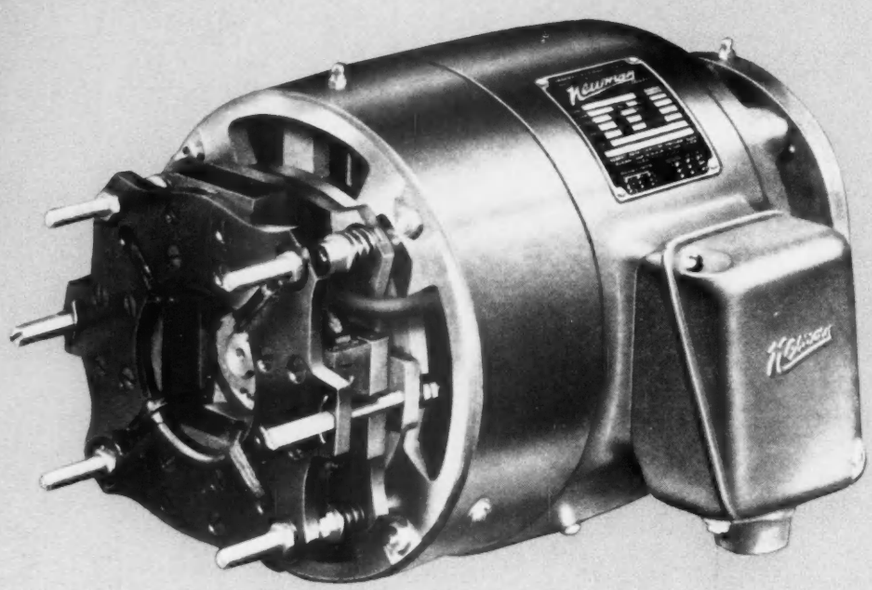
CONSTRUCTION AND OPERATION

The cast iron brake discs with brake linings bonded to both sides of it (1) is mounted on a steel hub (2) which is keyed to an extension of the motor shaft (3) at the non-drive end and secured endwise against a shoulder on the shaft by a locknut and tab washer. Drive from the hub to the brake disc is by four steel pins (4) retained between the hub flanges and on which the disc is free to move endwise. One side of the armature (5) has four laminated cores attached to it, the other side being used as one of the stationary braking surfaces. The armature is free to move endwise on the guide pins (6) and the springs (7) clamp the disc between the armature and the non-drive end bracket (8) of the motor which is suitably machined as the other stationary braking surface. The magnet (9) is a cast iron plate carrying four special cores and windings and is secured endwise on the guide pins by locknuts.

When the magnet is energised the armature (5) moves against the pressure of springs (7) to close the gap between it and the magnet, thus removing the pressure on the brake disc. Four springs (10) move the disc along the hub until it comes to rest against two setscrews (11) which are adjusted to centralise the disc between the stationary braking surfaces. There is then a clearance (normally ·010"–·012") on both sides of the brake disc and the motor is free to run.

The retarding torque of a particular brake can be adjusted (within limits) by altering the clamping pressure due to springs (7) by screwing back the locknuts (12).

Two manual release screws (13) which project through the brake cover (14) are provided for releasing the brake mechanically. These screws are threaded in the magnet plate but pass through clearance holes in the armature plate. Thus, when these screws are turned several times anti-clockwise the locknuts (15) eventually pull the armature plate back releasing the pressure on the brake disc. The position of the locknuts (15) relative to the armature can be adjusted to give quick release by only a turn or so of the screws and hand wheels can be fitted to the release screws when frequent use of this facility is required.

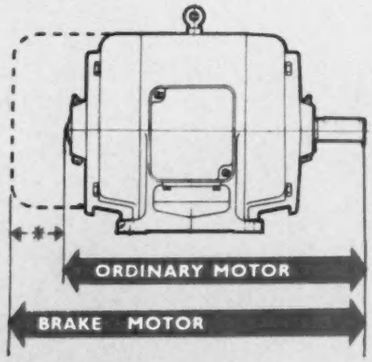


A BRAKE for FRACTIONAL to 40 h.p. MOTORS

Newman were the first British company to introduce a complete range of brake motors from fractional up to 40 h.p. incorporating a disc type electro-magnetic brake as an integral part of the motor design. The motors themselves may be drip-proof or totally enclosed and are standard in every respect apart from special non-drive end brackets on which the brakes are mounted and the extension of shafts to carry the brake disc hubs. It is the brake mechanism which provides the most interesting story. Operating on the disc principle and being "built-in" to the motor the brake has low inertia and is amazingly compact, powerful and efficient. The brake incorporates a new electro-magnet design, is operated from the normal A.C. supply and is of the "fail to safety" type. Some idea of the unique design of the brake and its compactness is given below.

BRAKES

Seven sizes of brake giving a total torque range 3–120 lb. ft. (a range of torques can be available for each horsepower/frame size of motor so that, within limits, the retarding torque may be matched to the needs of the application rather than the speed or h.p. of the motor).



COMPACTNESS

An indication of the power for size ratio of Newman brake motors is given by this scale drawing—a 3 h.p., 4 pole brake motor with a maximum retarding torque of 14½ lbs. ft. is only 3¼" longer than an ordinary motor of the same rating. In no case does the brake project beyond the present diameter of the motor.

Newman

Electric Motors from 1/16 to 600 H.P.

EXTERNAL COMPACTNESS

INTERNAL PERFECTION

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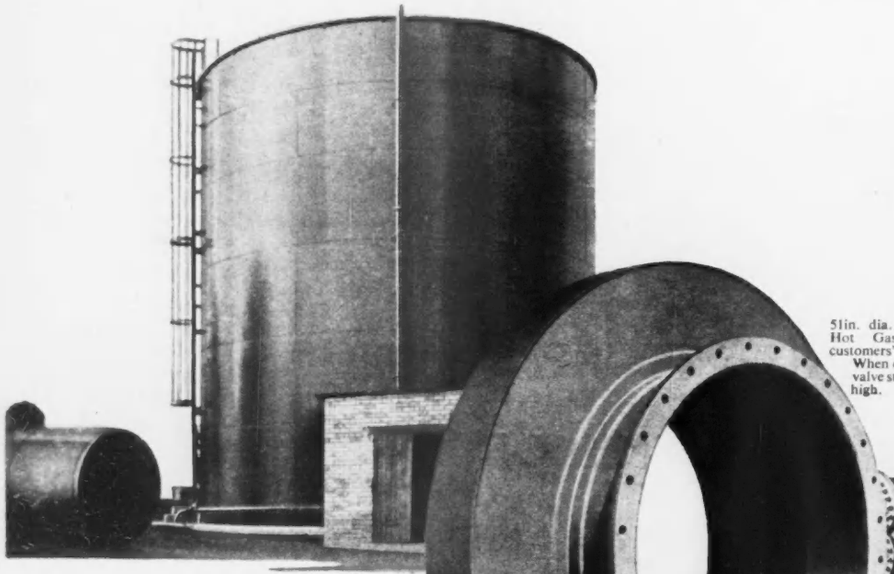
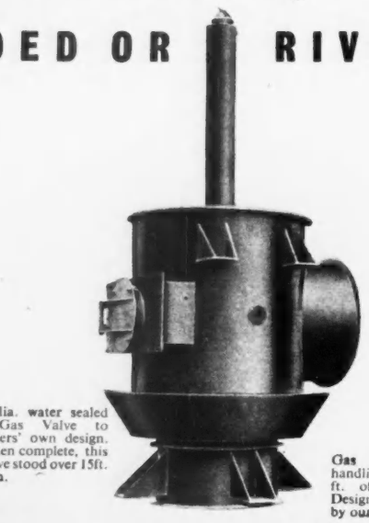
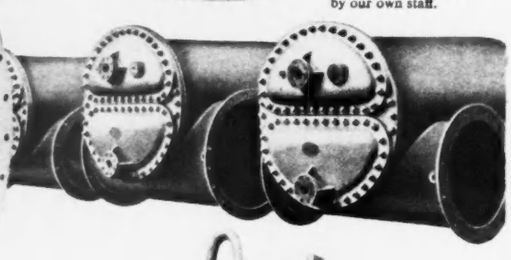


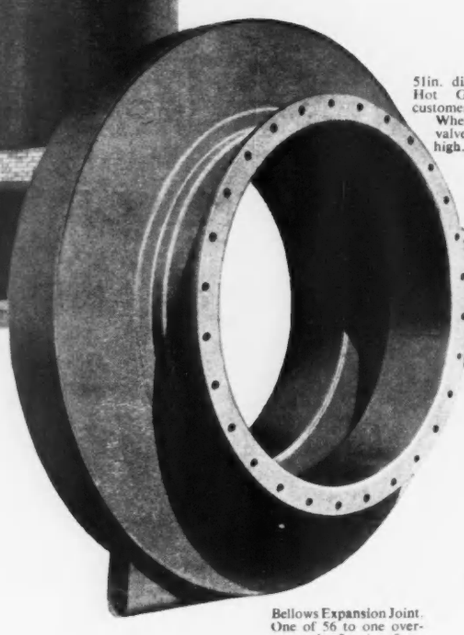
36ft. dia. by 37ft. high open top, all butt-welded Tar Storage Tank.



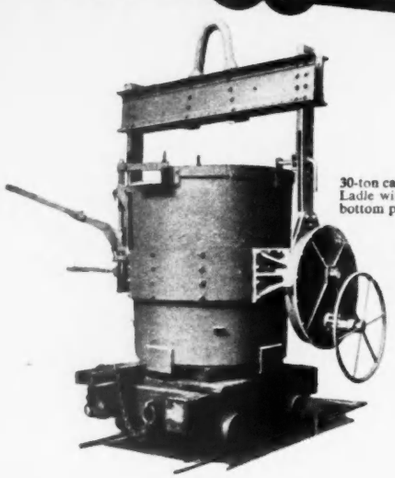
51in. dia. water sealed Hot Gas Valve to customers' own design. When complete, this valve stood over 15ft. high.



Gas Heaters, each handling 6,000,000 cu. ft. of gas per day. Designed and developed by our own staff.



Bellows Expansion Joint. One of 56 to one overseas order for sizes from 3in. to 48in. dia.



30-ton capacity Foundry Ladle with both lip and bottom pouring gear.

Widely experienced in producing intricate work involving difficult development, conical rolling, special welding techniques and sequences to British and American Standards.

Equipped for stress relieving, shotblasting, metal spraying and acid pickling.

Own competent erection staff for all field work both at home and overseas.

Work produced to customers' specifications and drawings, or full collaboration in design development.

ENQUIRIES INVITED

FIRTH BLAKELEY SONS & COMPANY LIMITED

Gas, Chemical and Construction Engineers

VULCAN IRONWORKS · CHURCH FENTON · YORKSHIRE

Telephone: Barkston Ash 234/5 **Telegrams: Blakeleys, Church Fenton**

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MARCONI
VALVE
VOLTMETERS

for use in laboratories, production lines and teaching establishments

Marconi Instruments, internationally renowned in the field of electronic measurement, present two of the latest models in their range of voltmeters

TYPE TF 1300

MEASURES A.C.:
50 mV to 100 V
20 c/s to 300 Mc/s
MEASURES D.C.:
100 mV to 300 V
MEASURES OHMS:
50Ω to 5MΩ

TF 1300—accurate, reliable, low-priced—has five a.c. measurement ranges, five d.c. ranges, and two ohms ranges. Zero stability is of a high order, and both a.c. and d.c. inputs are isolated from the chassis. A skilful combination of performance and economy, the TF 1300 offers the highest value of any voltmeter in its class today.

TYPE TF 1041B

MEASURES A.C.: 25 mV to 300V, 20 c/s to 1500 Mc/s
MEASURES D.C.: 10 mV to 1000 V
MEASURES OHMS: 0.02 Ω to 500 MΩ

Exceptional performance and versatility make the TF 1041B a leader among top-grade precision valve voltmeters. For a.c. measurement its input capacitance is only 1.5 μμF and input resistance is 0.5 MΩ at 10 Mc/s. For d.c. measurement the meter can be switched to give forward deflection for positive or negative voltages, or to allow centre-zero measurements. Optional accessories include multipliers for up to 20 kV d.c. and 2 kV a.c., a T-connector for voltage measurements on coaxial lines, and a wide-band coaxial dummy load. Send for leaflets AJ1,6.

MARCONI INSTRUMENTS

ELECTRONIC MEASURING EQUIPMENT, pH and MOISTURE METERS, INDUSTRIAL X-RAY APPARATUS, NUCLEAR POWER INSTRUMENTATION

Please address enquiries to MARCONI INSTRUMENTS LTD. at your nearest office:
London and the South: Marconi House, Strand, London, W.C.2. Telephone: COVent Garden 1234
Midlands: Marconi House, 24 The Parade, Leamington Spa. Telephone: 1408
North: 23/25 Station Square, Harrogate. Telephone: 67455
Export Department: Marconi Instruments Ltd., St. Albans, Herts Telephone: St. Albans 56161
TC 146

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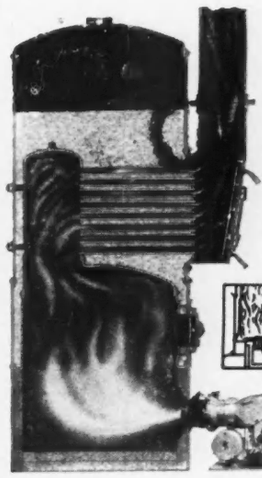

Coal — Coke — Wood or Oil-fired!

The COLTMAN 'ECONOMIC' Boiler construction allows for speedy adaptation. Possessing greater heating surface than most boilers, Thermal efficiency is increased. Oil-burning units can be fitted for land and marine purposes.

The 'ECONOMIC' has many important and outstanding features including — Quick Steaming Capacity. No Brickwork Setting. Economy of Floor Space. Accessibility giving Ease of Maintenance.

With Automatic Stoker or Burner fully complies with the Clean Air Act.
(Feature illustration.) With 'NU-WAY' Fully Automatic Oil Burner.
(Inset.) With Ashwell & Nesbit Automatic Coal Stoker.

WALTER W. COLTMAN & CO. (BOILERS) LTD.
CENTRAL BOILER WORKS : LOUGHBOROUGH
Tel: Loughborough 2351 *Grams: Boilers, Loughborough*

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OVERHEAD · TRAVELLERS · ELECTRIC GOLIATH

LOCO STEAM

MARSHALL FLEMING CRANES

EST 1890

OVER HEAD

DELLBURN WORKS MOTHERWELL · SCOTLAND
Telephone: Motherwell 50 Telegrams: "Dellburn" Motherwell

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DOUBLE HERMETAL BOND

STRUCTURAL PLASTIC

DISCOVER NEW WAYS
of cutting time and cost in making parts and components and for many types of repairs. DOUBLE BOND—an entirely new material—can be used for jointing, filling and moulding, or fabrication of actual parts. This versatile self-setting structural plastic is available in two grades; one moulds like putty for filling in depth, the other spreads like cream for shallower and larger areas. Both set like lead, machine like brass and can be used as a cold solder. Write for 7/6d. trial pack which includes both grades.

contact **Kenilworth**

MAKERS OF 'HERMETITE' JOINTING COMPOUNDS AND SUMMIT ALUMINIUM METALLIC PAINTS

THE KENILWORTH MANUFACTURING CO. LTD., WEST DRAYTON, MIDDLESEX
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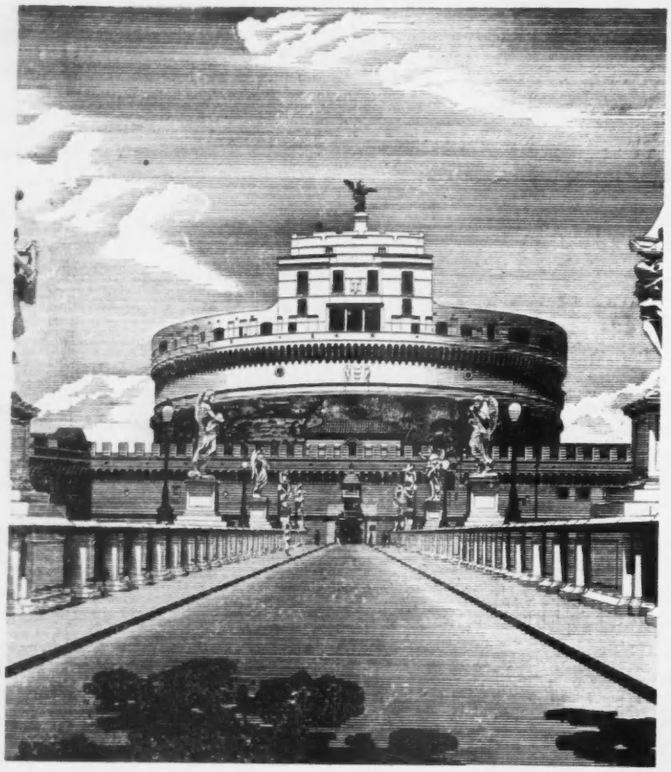
HADRIAN'S TOMB



Wonders of the World

HADRIAN, Roman Emperor, built this mausoleum for himself and his successors over 1800 years ago. Originally it was encrusted with magnificent marble and the circular wall was crowned by a cone of earth planted with trees. Hadrian also built the bridge which gives access to the tomb. The mausoleum eventually became the medieval citadel of Rome and is now known as the Castle of San Angelo.

The Wonders of the Modern World will be chronicled by posterity and will reveal the indispensable contribution of steel tubes to these achievements.

WELLINGTON TUBE WORKS LTD

For Steel Tubes and Steel Tube Fabrication

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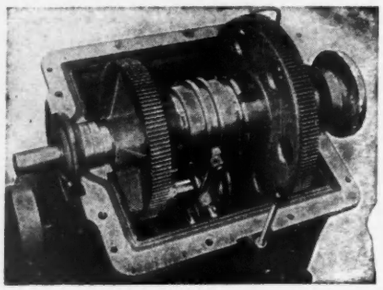
Powerful, Positive, Safe . . .



TAYLOR

Multiple Disc CLUTCHES

Resiliency, sensitivity, ease of control and the ability to perform continuous heavy duty without frequent adjustment, make Taylor Multiple Disc Clutches a popular choice for machine tool, plant, civil and heavy engineering. Such characteristics are ensured by:—Heat treatment and total enclosure of all operating parts; positive locking; single point adjustment and precision manufacture on modern plant. A Taylor Clutch is a self-contained unit, easily assembled, quickly fitted and produced to perform many years of strenuous work.

The Illustrations show a typical application. The Reid Gear Co., Ltd., required a powerful, sensitive and completely trustworthy clutch unit for their two-speed reduction gear, to transmit the enormous effort applied in actuating the emergency sluice gate on a Scottish Hydro-Electric Project. The features mentioned above qualify Taylor Clutches to satisfy such exacting demands because they constitute the very ingredients of strength and reliability—the choice was a Taylor Multiple Disc Clutch.

TAYLOR INDUSTRIAL CLUTCHES

TROWS UPPER WORKS · CASTLETON · LANCS.

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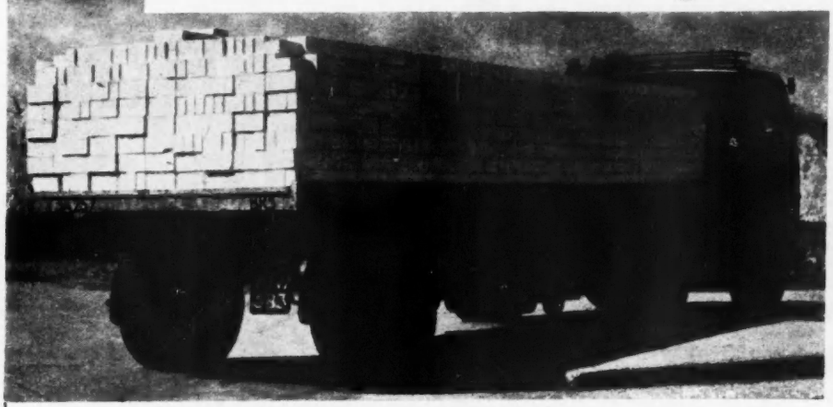
£500 worth of insulating bricks . . .



A consignment of M.P.25 Insulating refractory bricks destined for a Midlands Engineering works

. . . yet without them the furnaces in which they will be installed would consume the equivalent of an extra 65 tons of coal per annum to replace radiation heat losses and higher operational costs. A sound economic reason why Fosalsil Insulating bricks and M.P. Insulating refractories are now an accepted part of modern furnace practice. These high quality materials are designed to give long life and high thermal efficiency in all types of furnaces, boilers, and gas plant.

Medium temperature insulation can also be supplied in slab form—Fosalsil Lightweight Slab Insulation being available in sizes up to 36″ × 12″. This slightly compressible material possesses superlative insulating properties and is particularly suited for speedy installation over large wall surface areas of plated furnaces.

MOLER PRODUCTS LIMITED COLCHESTER

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Pumpin', heatin' n' coolin'

TYPE C.C.E. Fullway-direct-in-pipeline design, allowing gravity circulation when desired. Sizes 1¼in., 2in. and 3in.

Whether for Warnford Court in the heart of the City (as this installation by Messrs. M. & J. Lossos & Co. Ltd.)—for Tantivy Towers in the heights of Heythropshire or for the continuous round of industrial service—there is no finer tackle than Safran Pumps.

SAFRAN REGISTERED TRADE MARK PUMPS

SAUNDERS VALVE COMPANY LIMITED

SAFRAN PUMP DIVISION

DRAYTON STREET, WOLVERHAMPTON. 'PHONE 25531

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"TAKE MY TIP — USE SIFBRONZE EQUIPMENT!"

says Will the Welder

"DEMON" BLOWPIPES :—
General Duty and Cutting Models.

SIF-COLIBRI CUTTING MACHINE
The clockwork machine which turns a hand cutter into a precision machine cutter. Ideal for flame cutting on site.

SIF-COMBI PROFILE CUTTING MACHINE
An Automotic dual-purpose machine for all kinds of cutting work.

SIFBRONZE REGULATORS
Modern precision instruments giving constant pressure and volume.

SIFBRONZE CATSEYE GOGGLES
The most advanced type on the market.

If you want to know how Sifbronze equipment can help you, fill in the coupon right away.

Suffolk Iron Foundry (1920) Ltd., Stowmarket, Suffolk.

Please send me leaflets detailing Sifbronze equipment.

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HAMMERED OR HYDRAULIC PRESSED

FORGINGS

IN STEEL
BLACK OR MACHINED
TO 24 TONS

THE INCE FORGE CO. LTD.
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Increase production! by using

SCRIVEN MACHINE TOOLS

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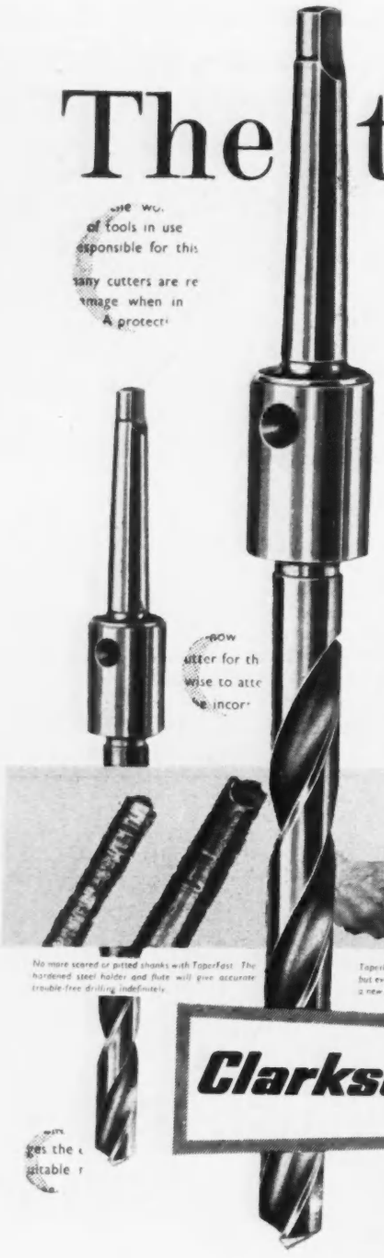
The twist drill news of the century



Some time ago Clarkson Autolock took the engineering world by storm, a revolutionary departure in milling chuck design that has since become a standard fitting in the modern factory.

To-day, Clarkson present TaperFast a new departure in drilling technique. TaperFast, bringing you the advantages of taper shank drilling right down to the smaller jobber sizes. TaperFast, offering you a host of advantages over conventional taper shank drills even in the larger range.

It's a money saver. Only the flutes need replacing — the hardened precision ground steel holder will last indefinitely. It's more accurate. The design allows the operator to see his work more clearly and get the machine head closer to the job.

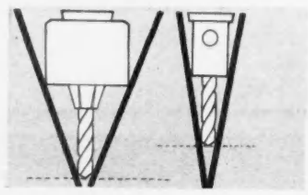
Its precision taper fit makes a perfect drive from spindle to drill eliminating snatch and breakage and costly damage to the machine spindle.

The introduction of TaperFast means setting up time and replacement time is reduced to a minimum, gaining a vast increase in production time.

Order TaperFast with confidence it's a tested product that will soon become a standard practice. Your nearest Clarkson depot will be glad to give you instant service.

No more scored or pitted shanks with TaperFast. The hardened steel holder and flute will give accurate trouble-free drilling indefinitely.

TaperFast flutes give many more holes per regrind, but even they must wear eventually. However, fitting a new flute is the work of a moment.



It's easy to see why operators like TaperFast. The revolutionary design reduces the excessive overhang of a conventional drill chuck, and gives a better field of vision.

Clarkson TaperFast TRADE MARK

Patent and Registered Design applied for.

CLARKSON (ENGINEERS) LTD., NUNEATON · Tel: 2261
BELFAST 32 Shaftesbury Square Belfast 20025 LEEDS 8a Britannia House, 1, Leeds 26369
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The Nitriding Process for Case-hardening Special Steels by Nitrogen offers

- Surface hardness up to 1100 D.P.H.
- Retention of full hardness after heating to 500° C.
- Maximum resistance to frictional wear and fatigue.
- Improved resistance to corrosion by water and steam.

Particulars from:—

NITRALLOY LIMITED
ATLAS WORKS SHEFFIELD, 4.
Telephone: Sheffield 26646. Telegrams: "NITRALLOY, SHEFFIELD."

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CASTINGS

HIGH QUALITY ENGINEERING & MACHINE TOOL CASTINGS

HEAT & WEAR RESISTING UP TO 10 TONS also in SPHEROIDAL GRAPHITE IRON & STEEL

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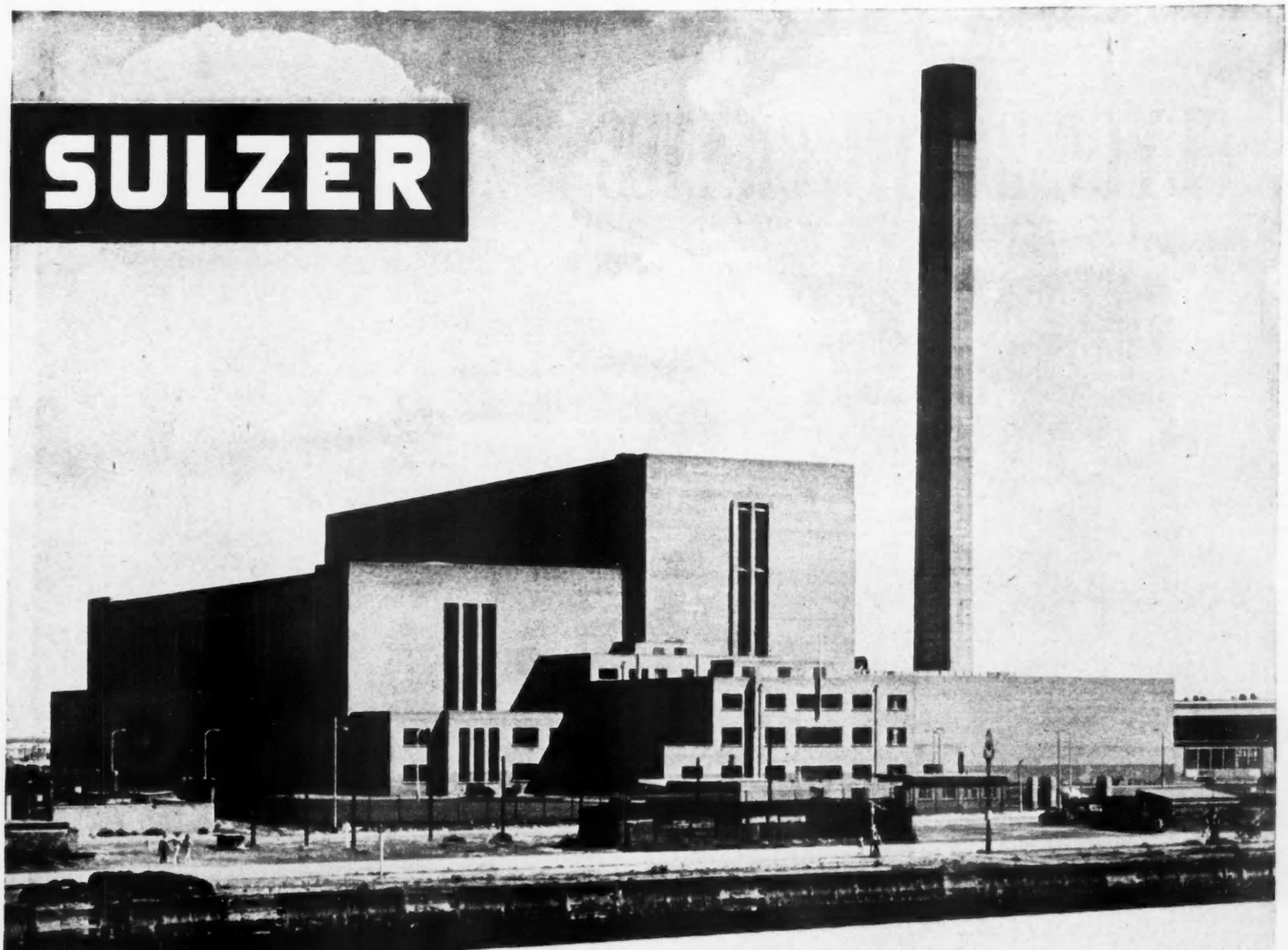
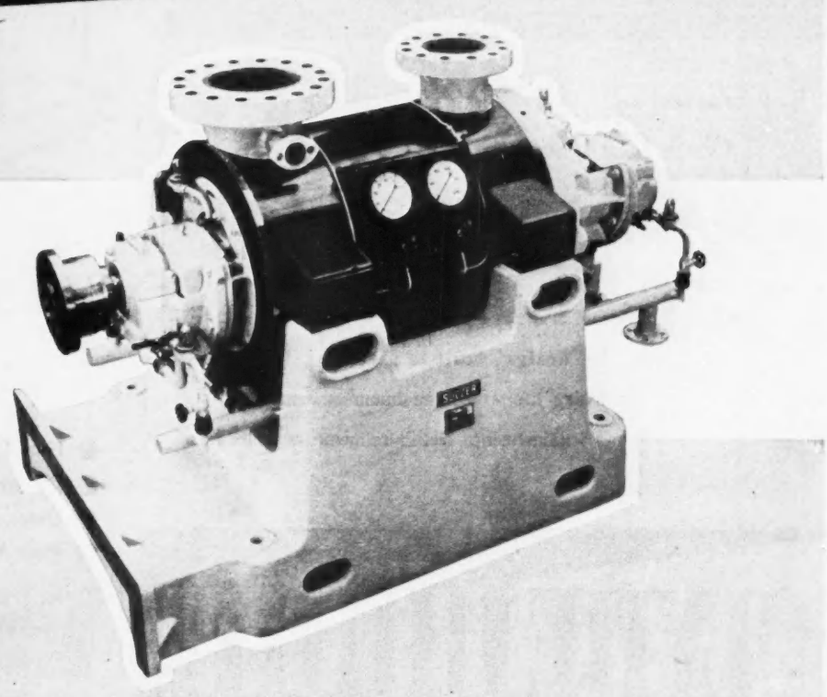
SULZER



One of eight electrically driven Sulzer Boiler Feed Pumps, each with a capacity of 650,000 lbs per hour, at a pressure of 1,240 lbs p.s.i. and a temperature of 260°F.

Installed in the South Denes Power Station, Great Yarmouth, for the Central Electricity Generating Board, Eastern Division



Telephone: MUSeum 7890

SULZER BROS. (LONDON) LTD.

Incorporating Hathorn Davey & Co. Ltd.

31 Bedford Square, London, W.C.1

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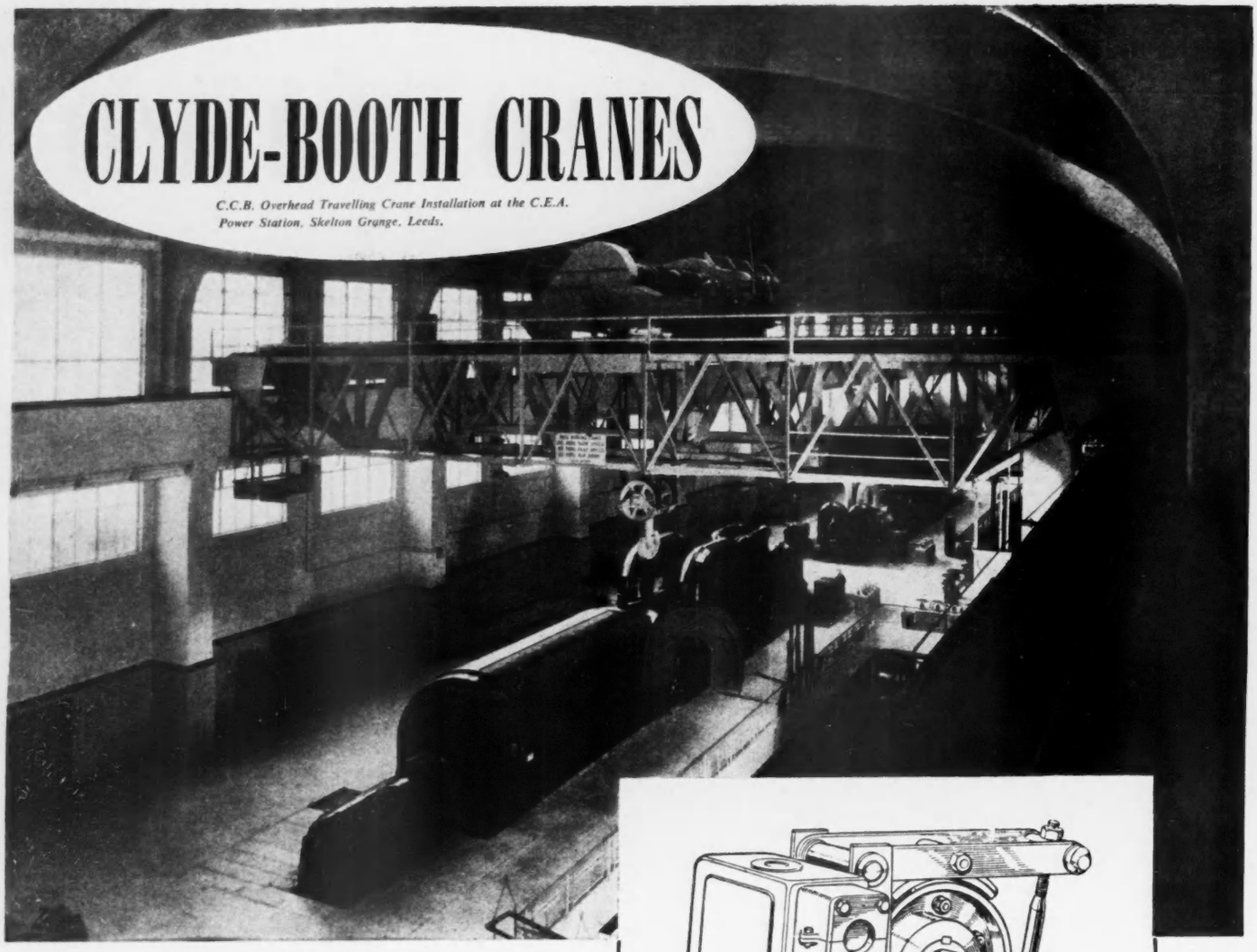
CLYDE-BOOTH CRANES

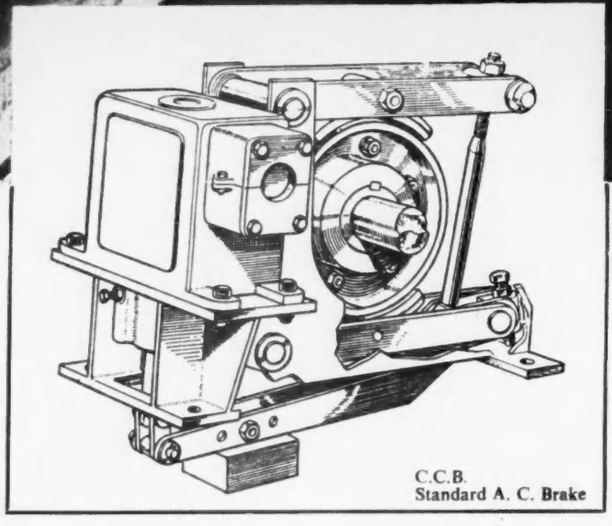
C.C.B. Overhead Travelling Crane Installation at the C.E.A. Power Station, Skelton Grange, Leeds.



Salient Features of
Clyde-Booth Design . . . .

ELECTRIC BRAKES....

The C.C.B. Solenoid brake is a compact all steel design, built to give long working life with a minimum amount of adjustment. Detail refinements include:



C.C.B.
Standard A. C. Brake

- **Hardened and ground pins working in phosphor bronze bushed links.**
- **Die pressed friction linings ground to form after fitting.**
- **Quick and easy adjustment to compensate for lining wear.**
- **Wide brake drum and shoes provide large friction area.**

CLYDE BOOTH

CLYDE CRANE & BOOTH LTD. *Incorporating:*

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Tel.: Pudsey 3168 (6 lines) Grams: "Cranes," Rodley, Telex. Telex 55159.

Clyde Crane & Engineering Co.,
MOSSEND, Lanarkshire.
Tel.: Holytown 412 (6 lines). Grams: "Clyde," Motherwell, Telex. Telex 77443.

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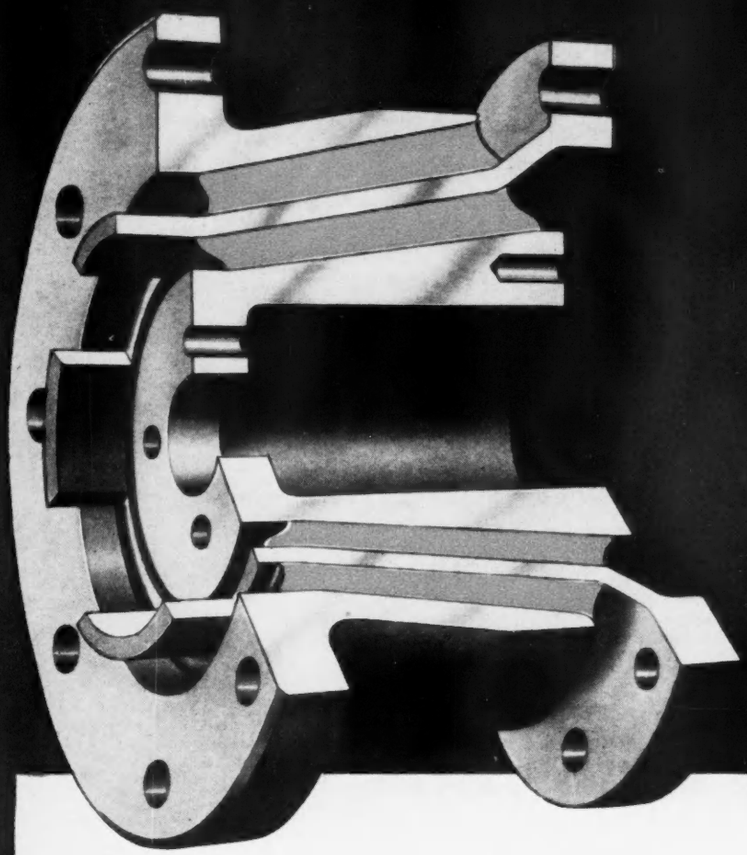


Double-cone couplings

(PATENTED)

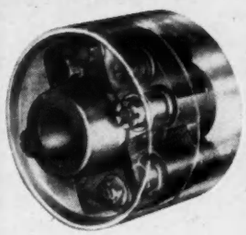
Damp Torsional Vibration, Resist Thrust, Absorb Shock Loads

A high degree of torsional flexibility combined with large torque capacity singles out the Double-Cone Coupling for drives in which torque fluctuations and torsional vibration must be controlled.

The design is suitable for torques up to 100,000 lb. ins. and torsional deflections from 5°-10°. It permits some angular misalignment and is designed to resist end thrust.

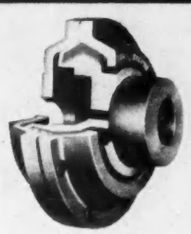
Available in a number of standard sizes, the Double-Cone Coupling is of robust construction and requires no maintenance.

SOME OTHER METALASTIK COUPLINGS



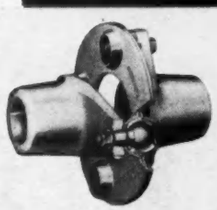
TRAILING LINK

Accommodates exceptional parallel misalignment. In range of sizes to transmit 1-20 h.p. per 100 r.p.m.



BICONE

For marine and other applications, transmits thrust, absorbs torsional vibration and accommodates misalignment. For drives of 5-10 h.p. per 100 r.p.m.



UNIVERSAL

Accommodates a large amount of angular misalignment with very low resistance. In sizes to transmit 0·3–3 h.p. per 100 r.p.m.

METALASTIK

LEICESTER

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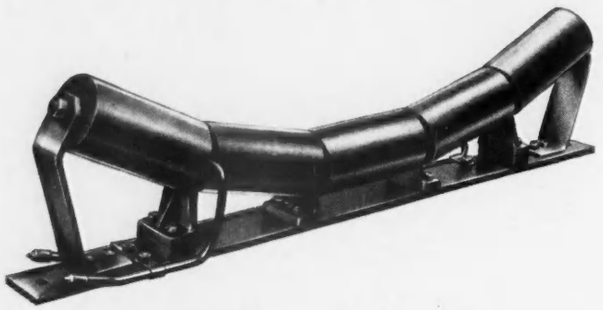
At their new fully-mechanised foundry at Tipton, Bilston Foundries Ltd. are producing cast iron baths at the rate of 60 per hour, in a wide range of styles. This output involves handling and processing a maximum of 350 tons of moulding sand per hour, all of which passes over Westwood Dawes conveyors at some stage. A total of 24 belt conveyors were designed, manufactured and installed by us on behalf of Messrs. Pneulec Ltd.

A bath a minute!

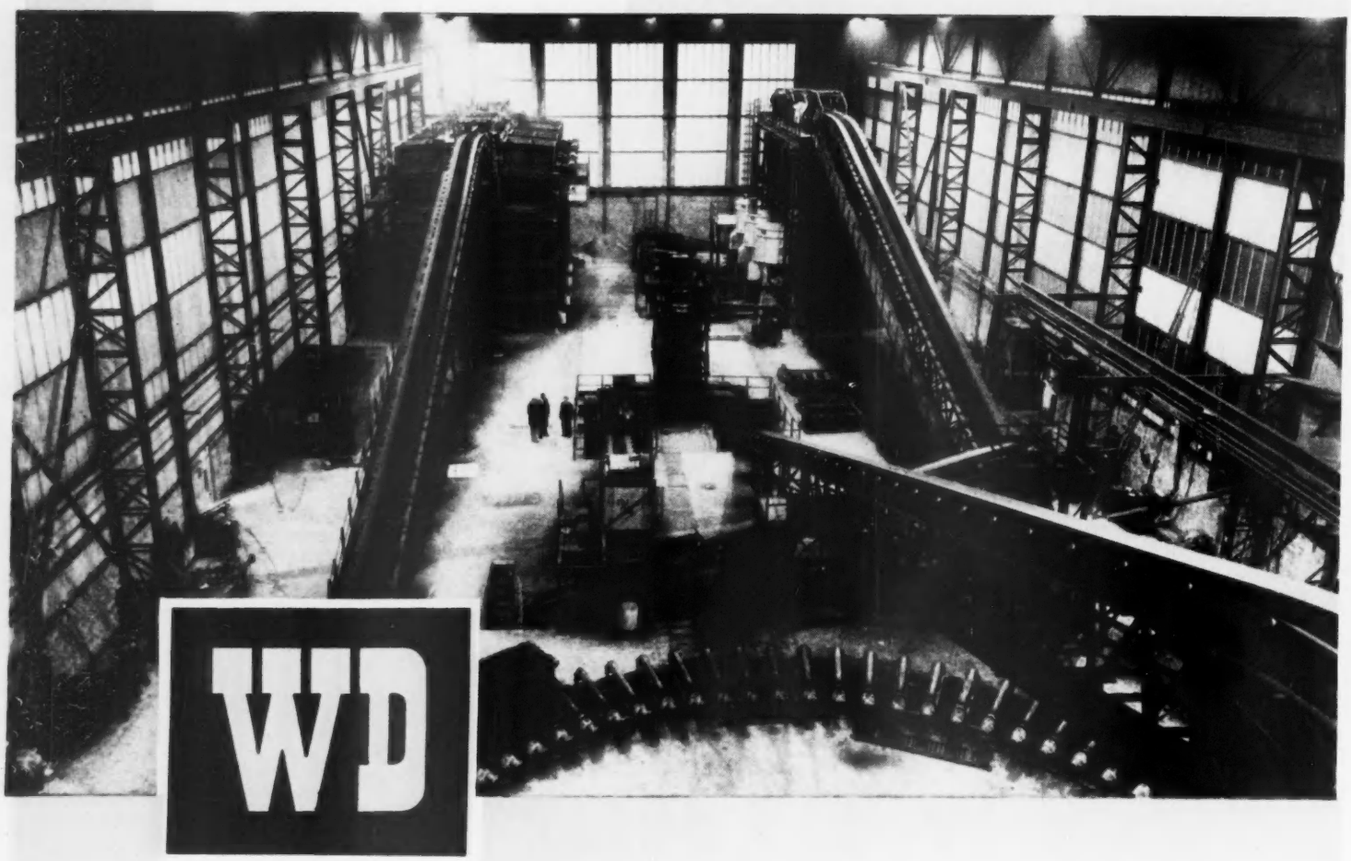


Westwood Dawes idlers are available with either grease packed self-lubricating bearings or with external grease nipples and one side lubrication pipes.

3 Roller sets can have 4", 5" or 6" diameter rolls.
5 Roller sets can have 5" or 6" diameter rolls.

A full range of tubular return idlers, rubber disc returns, impact idlers, steel pulleys and tension gear, etc., is also available.

Send for our Catalogue now!



WD

BELT CONVEYORS BY WESTWOOD DAWES

WESTWOOD DAWES & CO. LTD.
Bowling Green Road, Stourbridge, Worcs. Tel: 4741 (4 lines)

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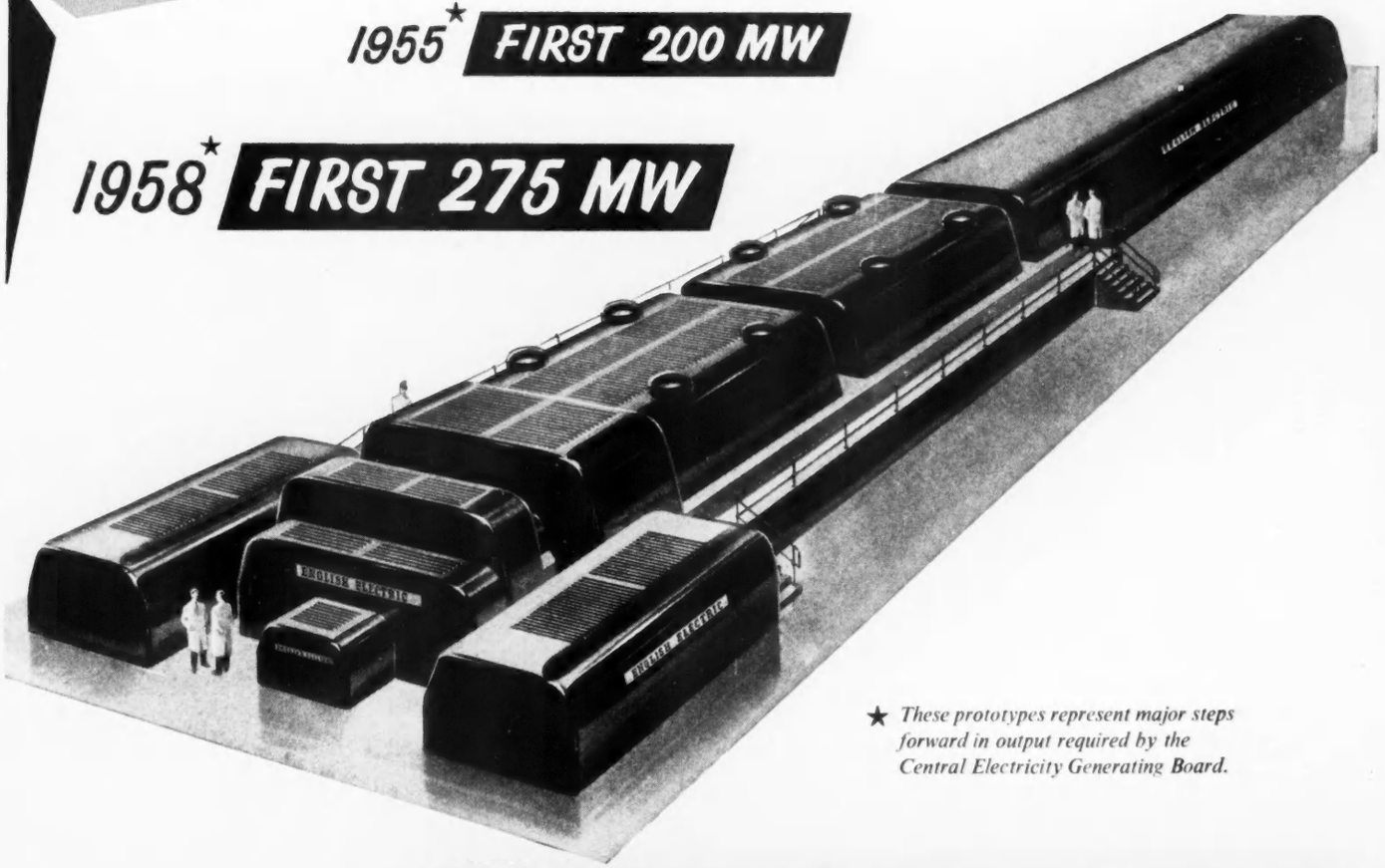
1955★ FIRST 200 MW

1958★ FIRST 275 MW



★ *These prototypes represent major steps forward in output required by the Central Electricity Generating Board.*

NOW★ FIRST 350 MW

The ENGLISH ELECTRIC Company Limited has received instructions from the Central Electricity Generating Board to put in hand Britain's first two 350 MW, 3,000 r.p.m. in-line turbo-alternator sets for their Drakelow 'C' power station.

OPERATING CONDITIONS: 2,300 p.s.i.g., 1,050°F., reheat to 1,050°F.

All the above turbines are tandem compound units and are the first of their type and size developing all their power in *one* shaft.

—AND FOR THE FUTURE

The ENGLISH ELECTRIC Company now has even more advanced designs available comprising cross-compound units on two shafts and also units operating at supercritical pressures.

'ENGLISH ELECTRIC'

first and foremost

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

Steam Turbine Division, Rugby

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

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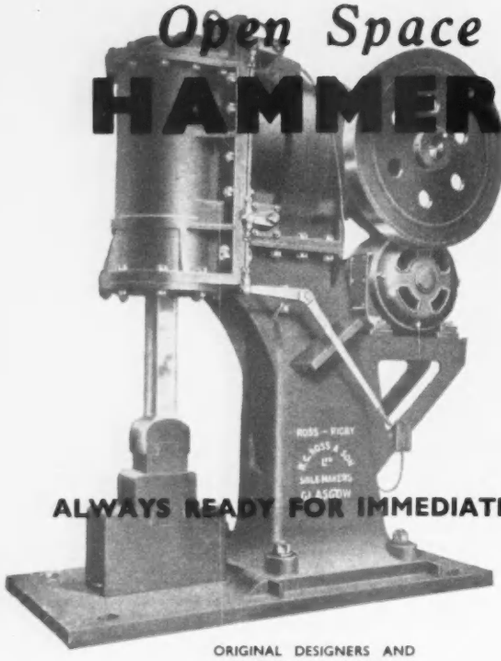

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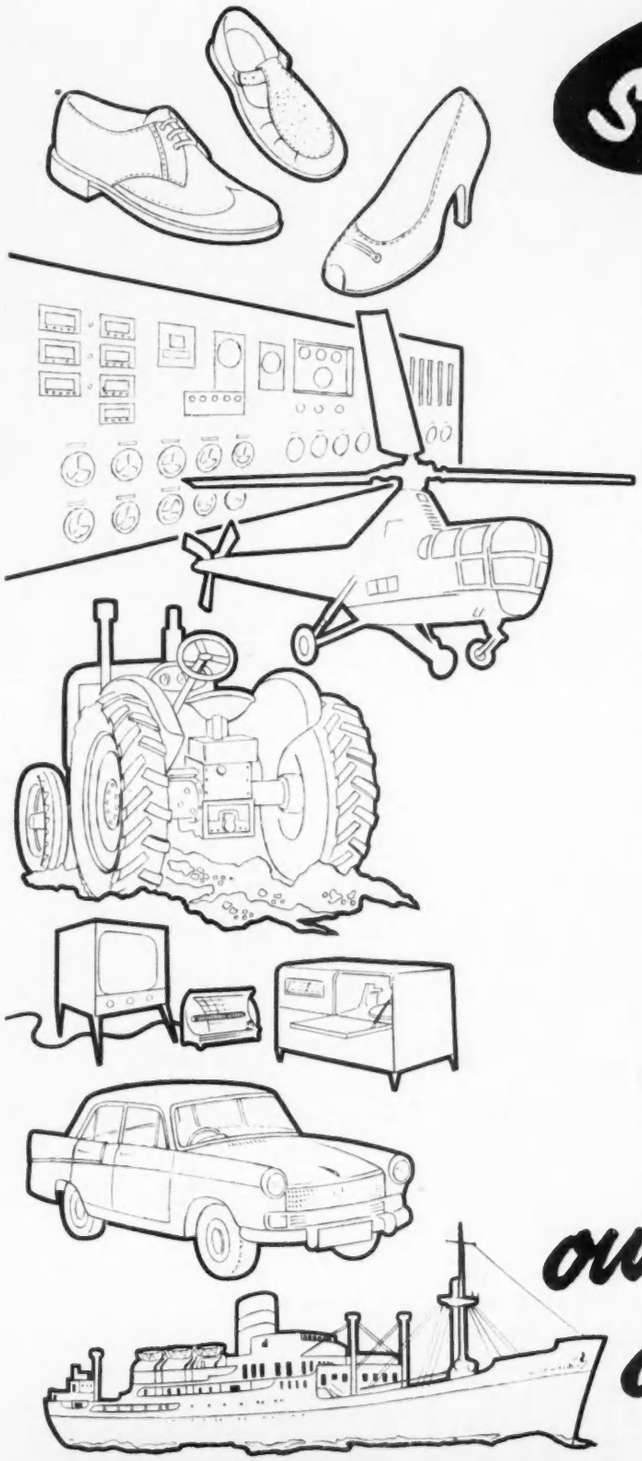

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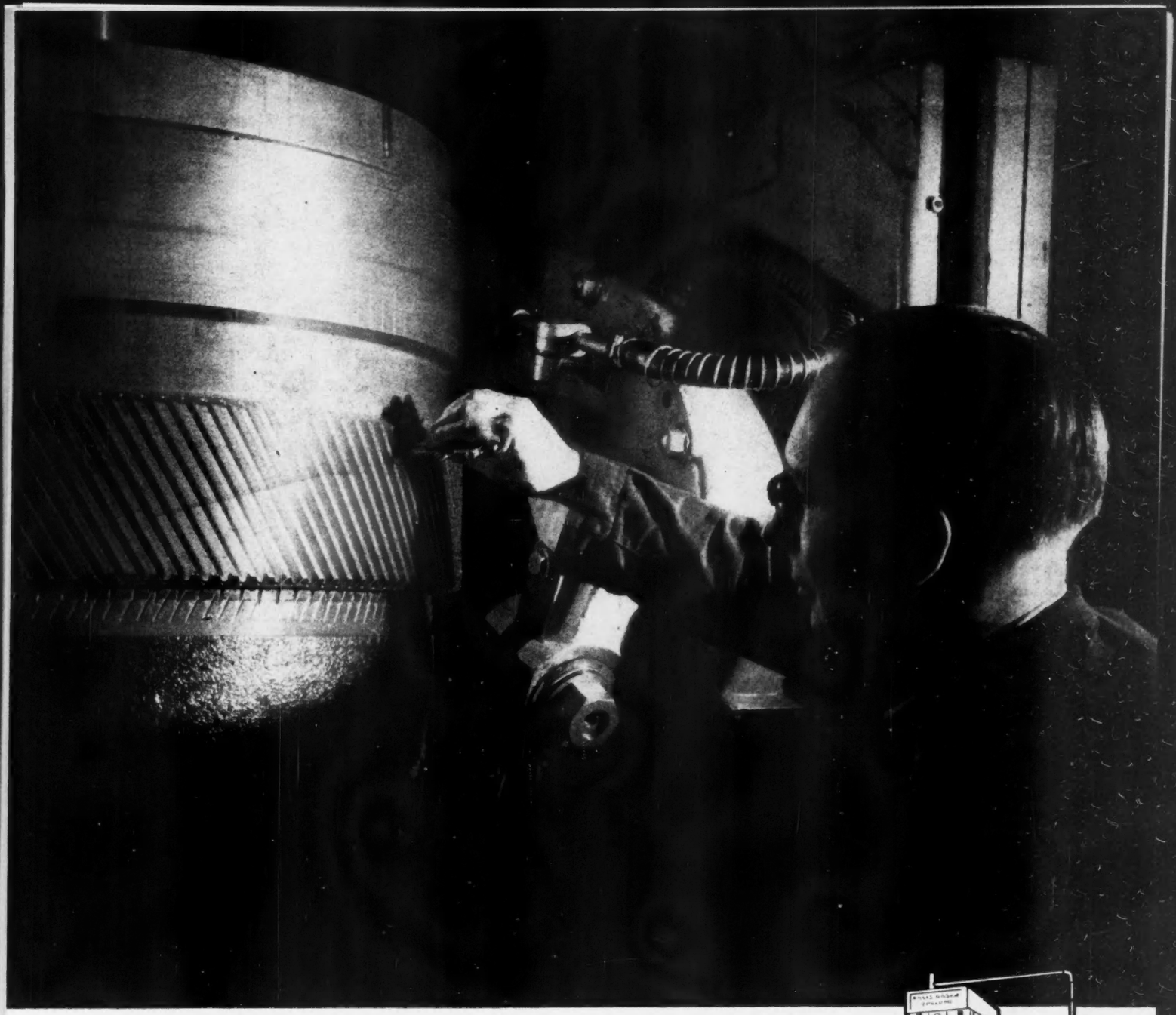

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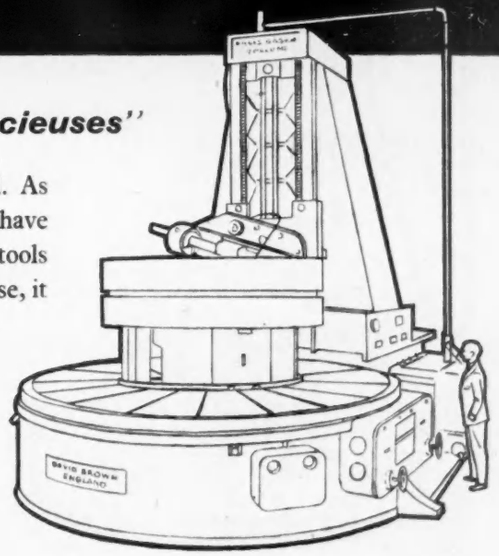

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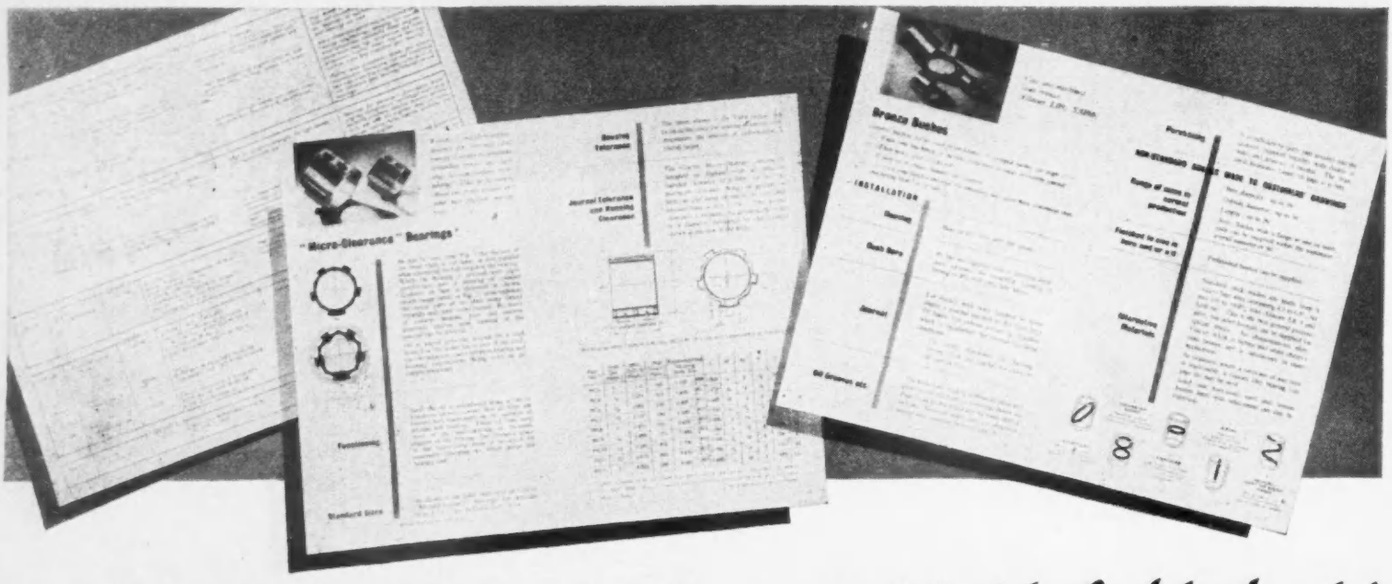

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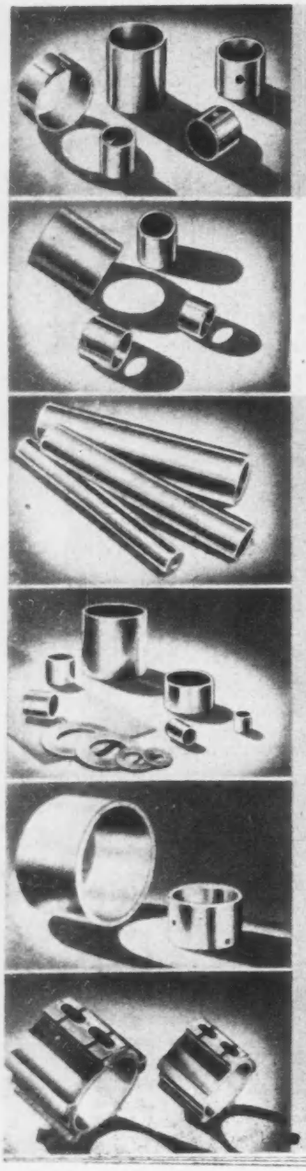

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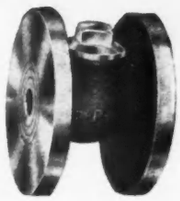

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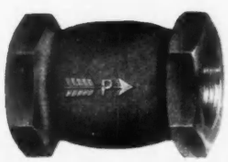

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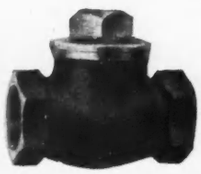

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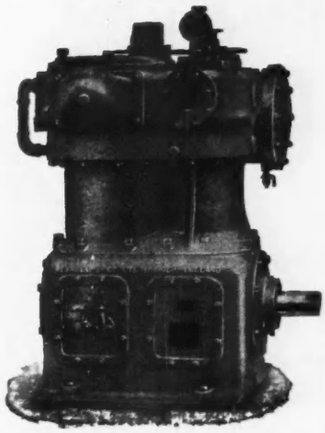

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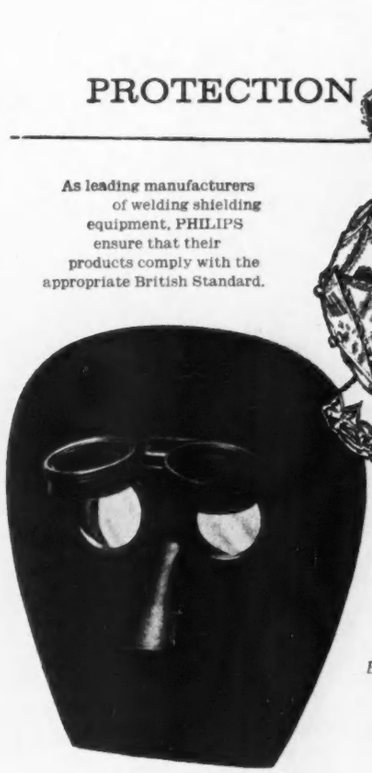

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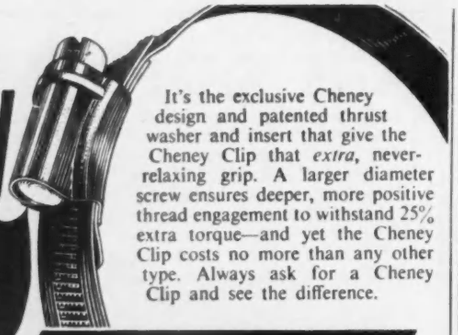

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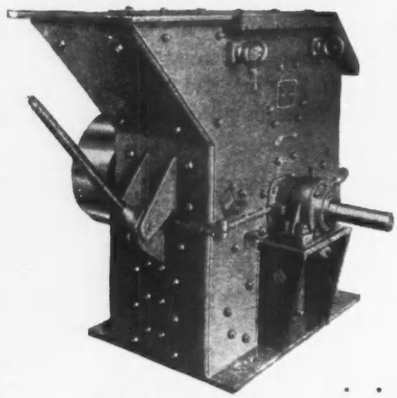

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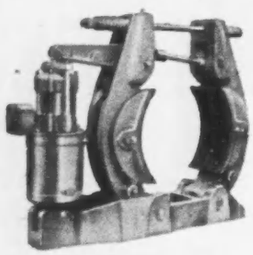

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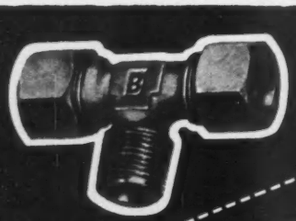

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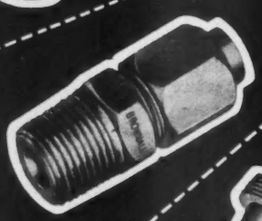

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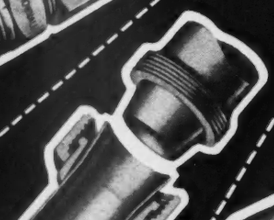

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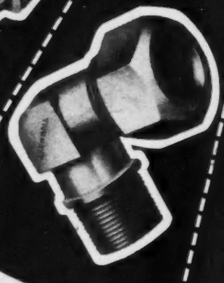

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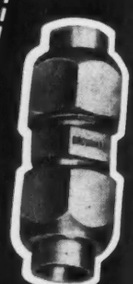

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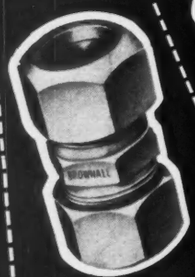

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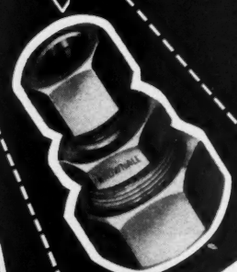

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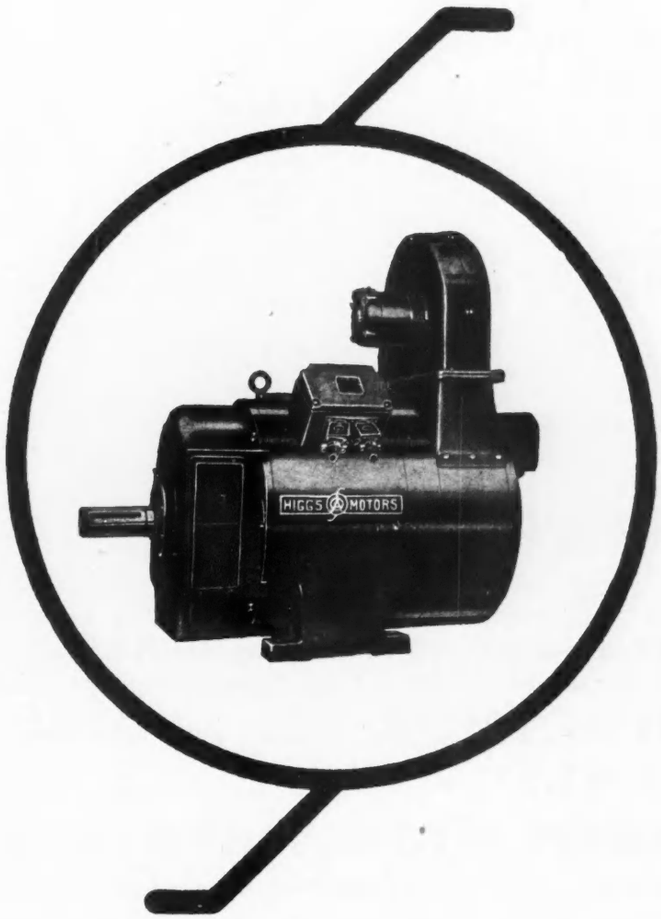

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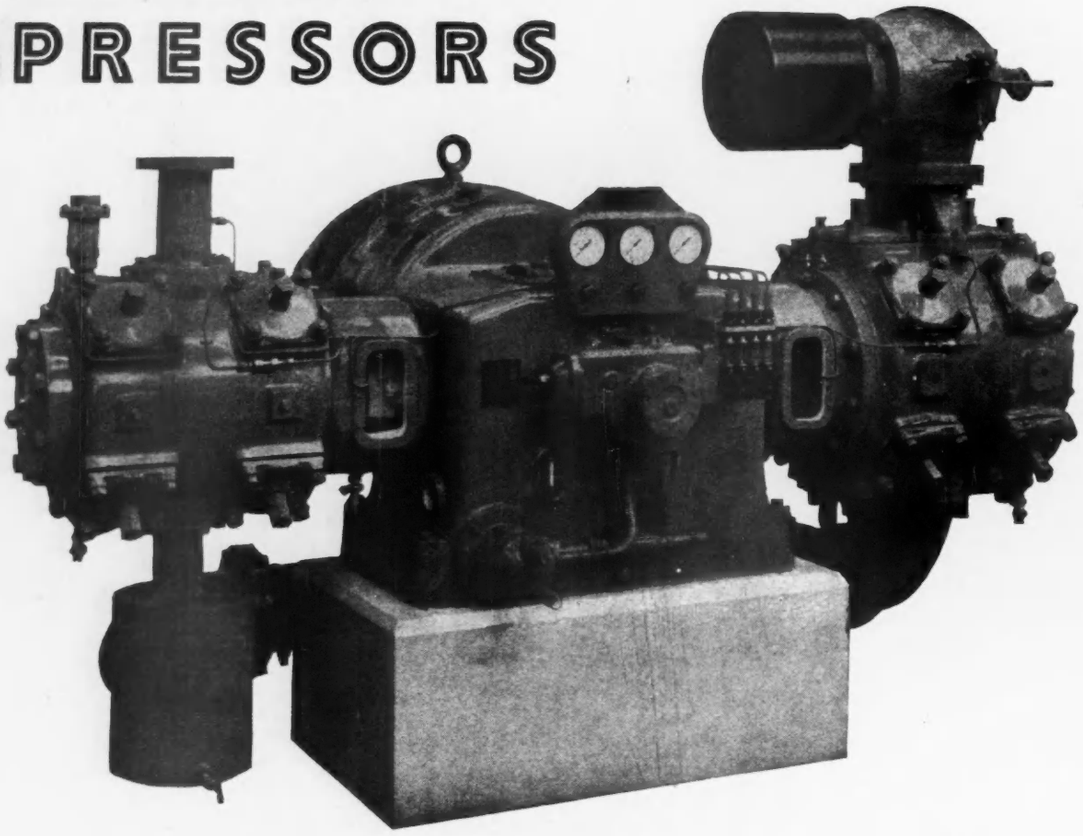

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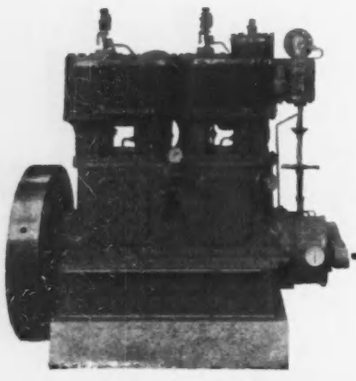

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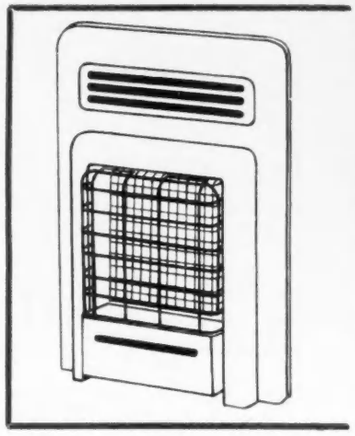

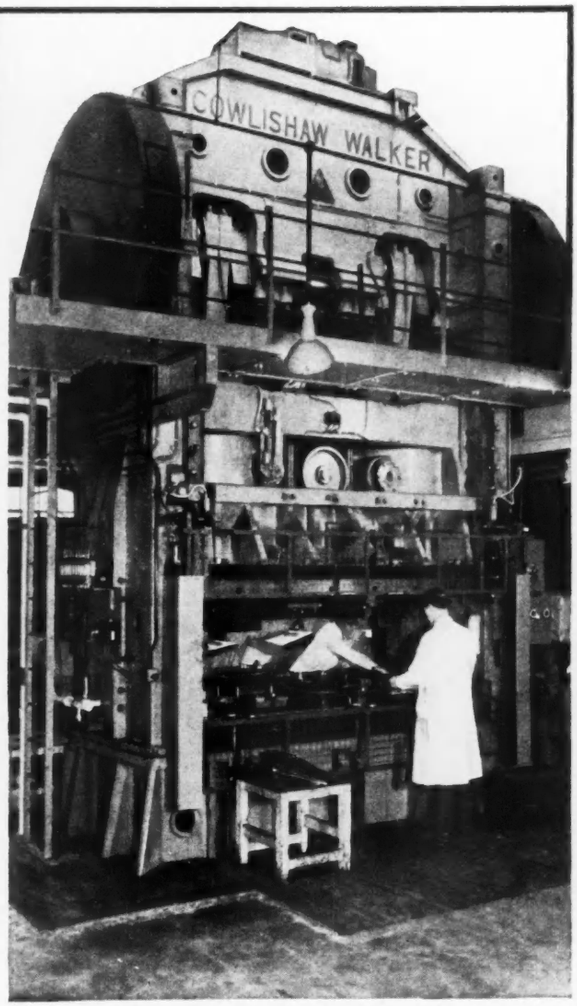

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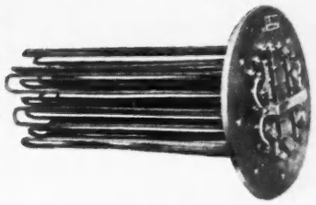

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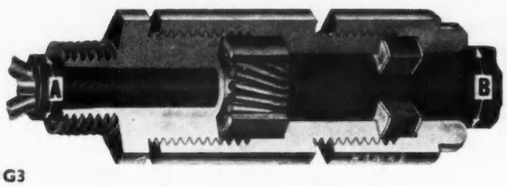
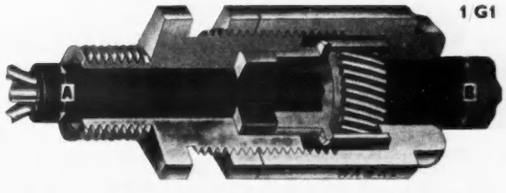
Hawke Compression Type Glands and Sealing Boxes are used throughout the world. Recommended where armoured cables are used and where flameproof installations are required. Specified for oil Refineries, atomic power plants and all hazardous areas. In regular use by Government Departments, the Central Electricity Authority, the National Coal Board, Chemical Industries, Oil Refineries and Steel Companies.



9 G3



1 G1

★ **DURGAPUR Steelworks, INDIA, has specified standard Hawke cable glands** (specially treated) **7/G3, 8/G3, 9/G3, G/11**

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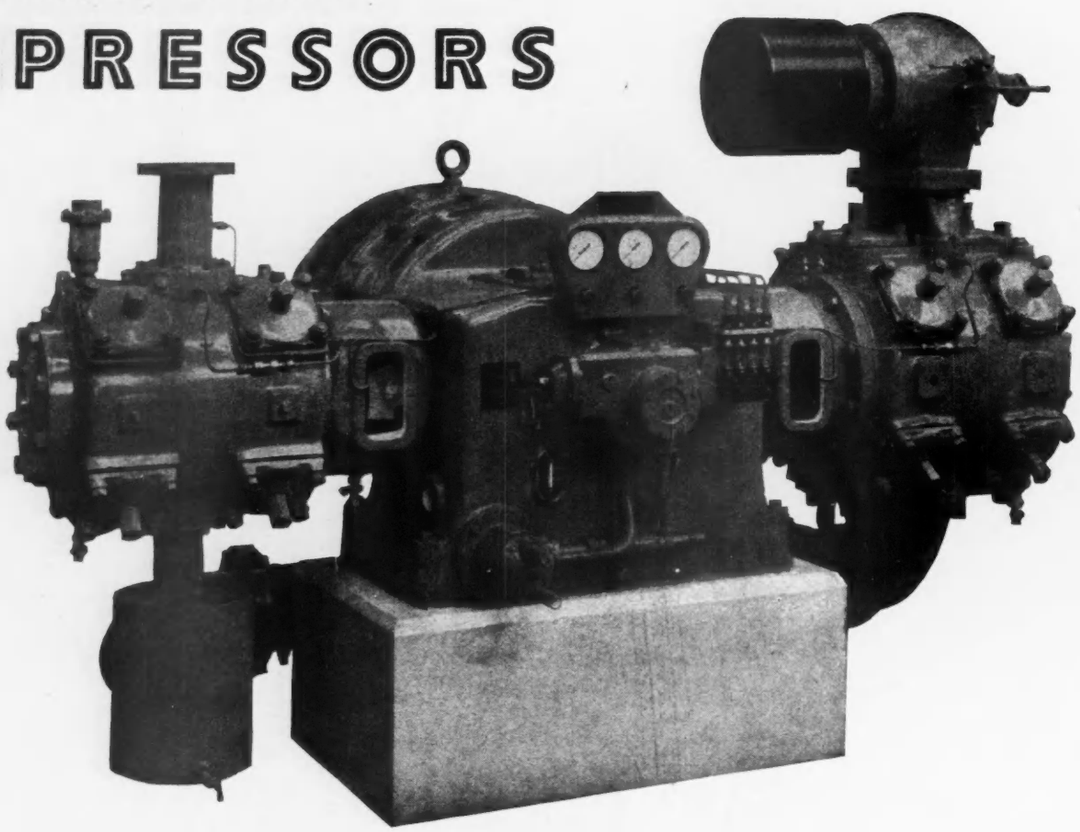
ALLEY

BALANCED OPPOSED COMPRESSORS



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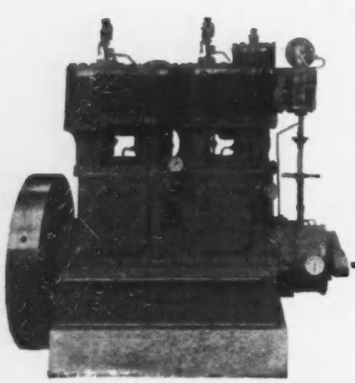

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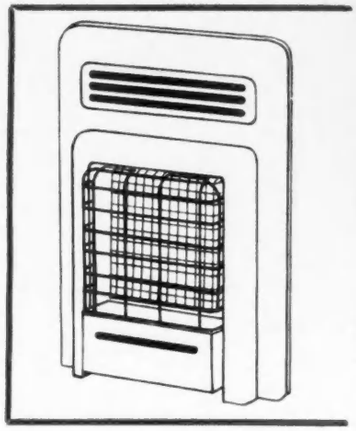

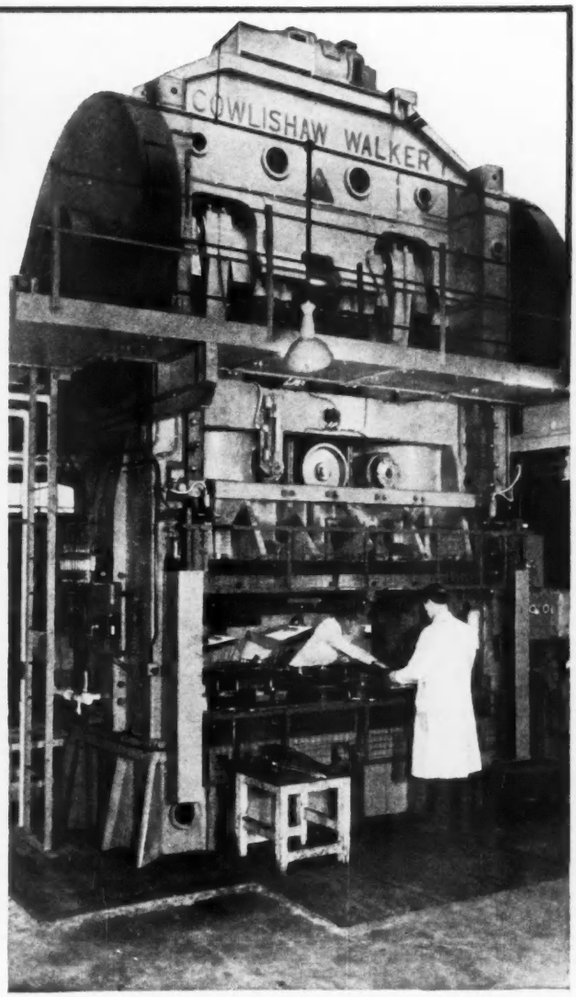

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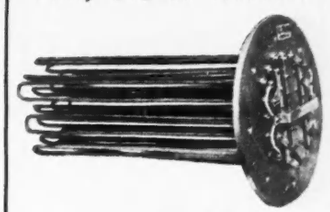

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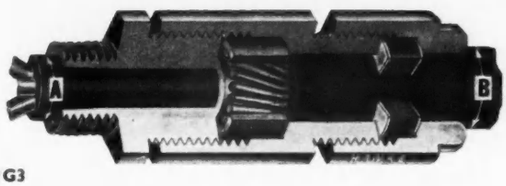

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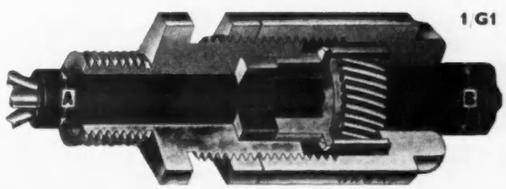

1 G1

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HAWKE CABLE GLANDS LTD.

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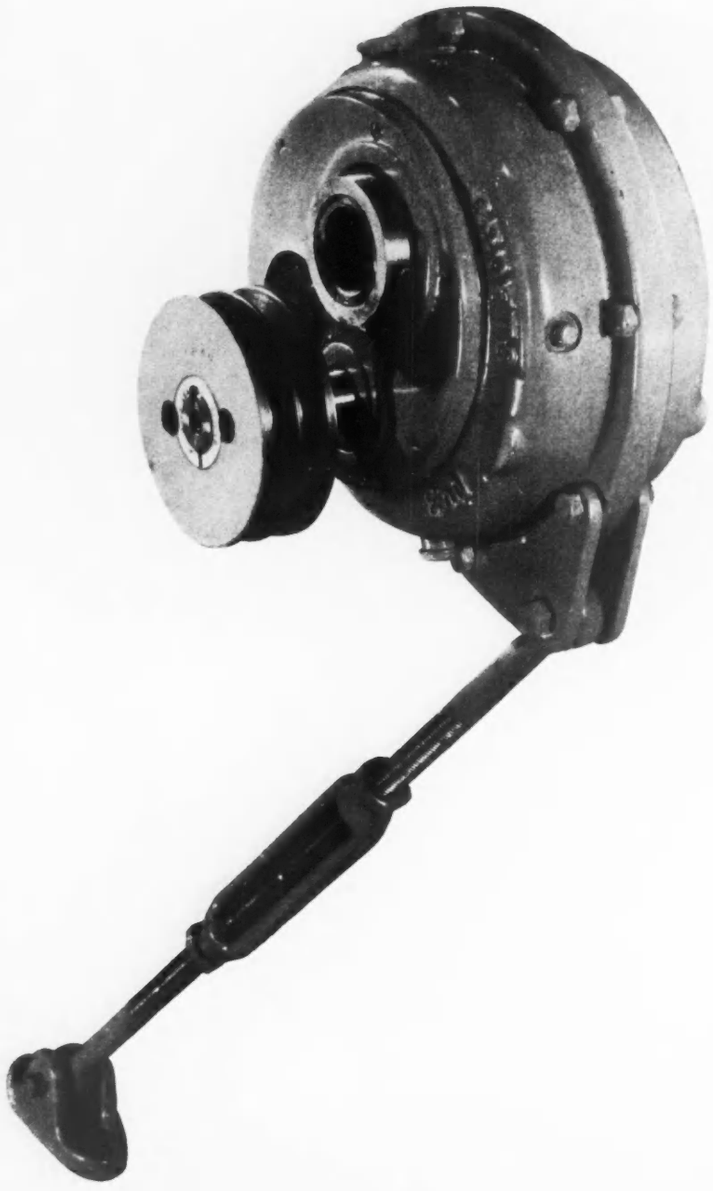

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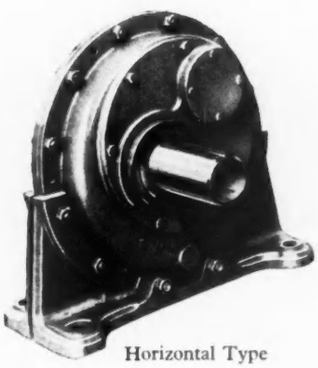
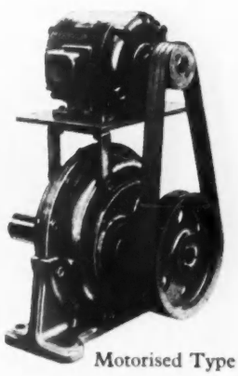


Horizontal Type

Vertical Type



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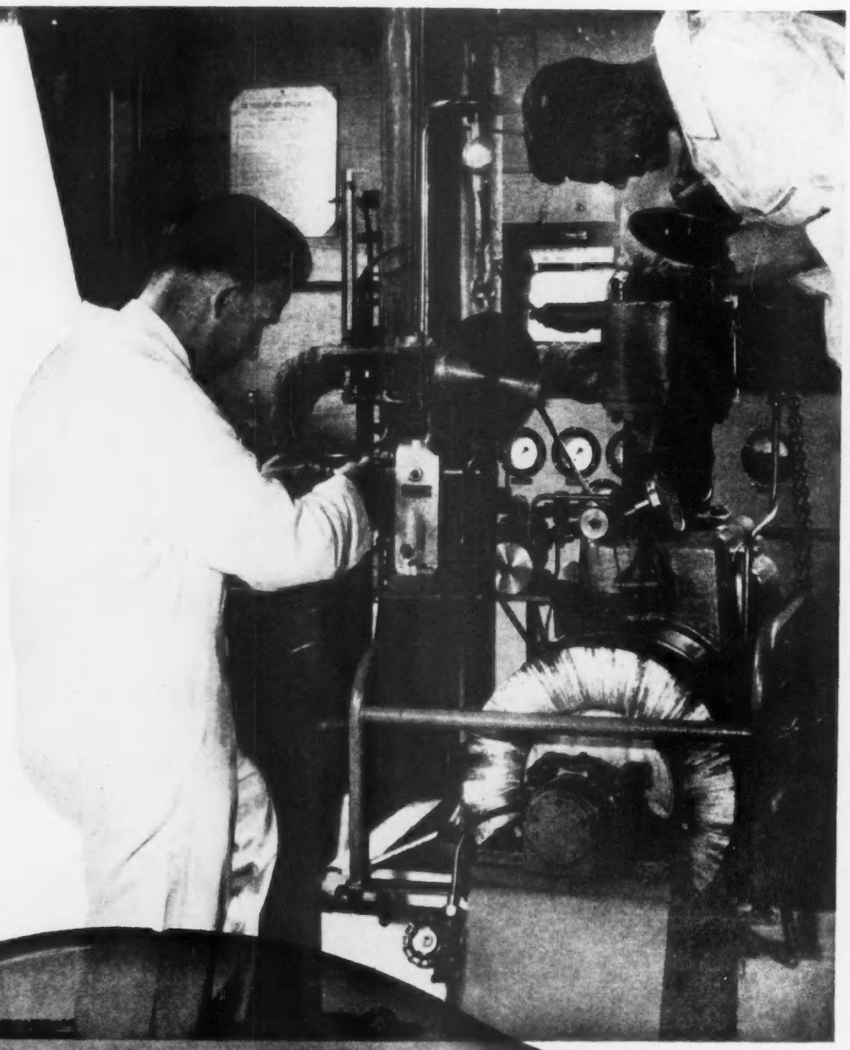

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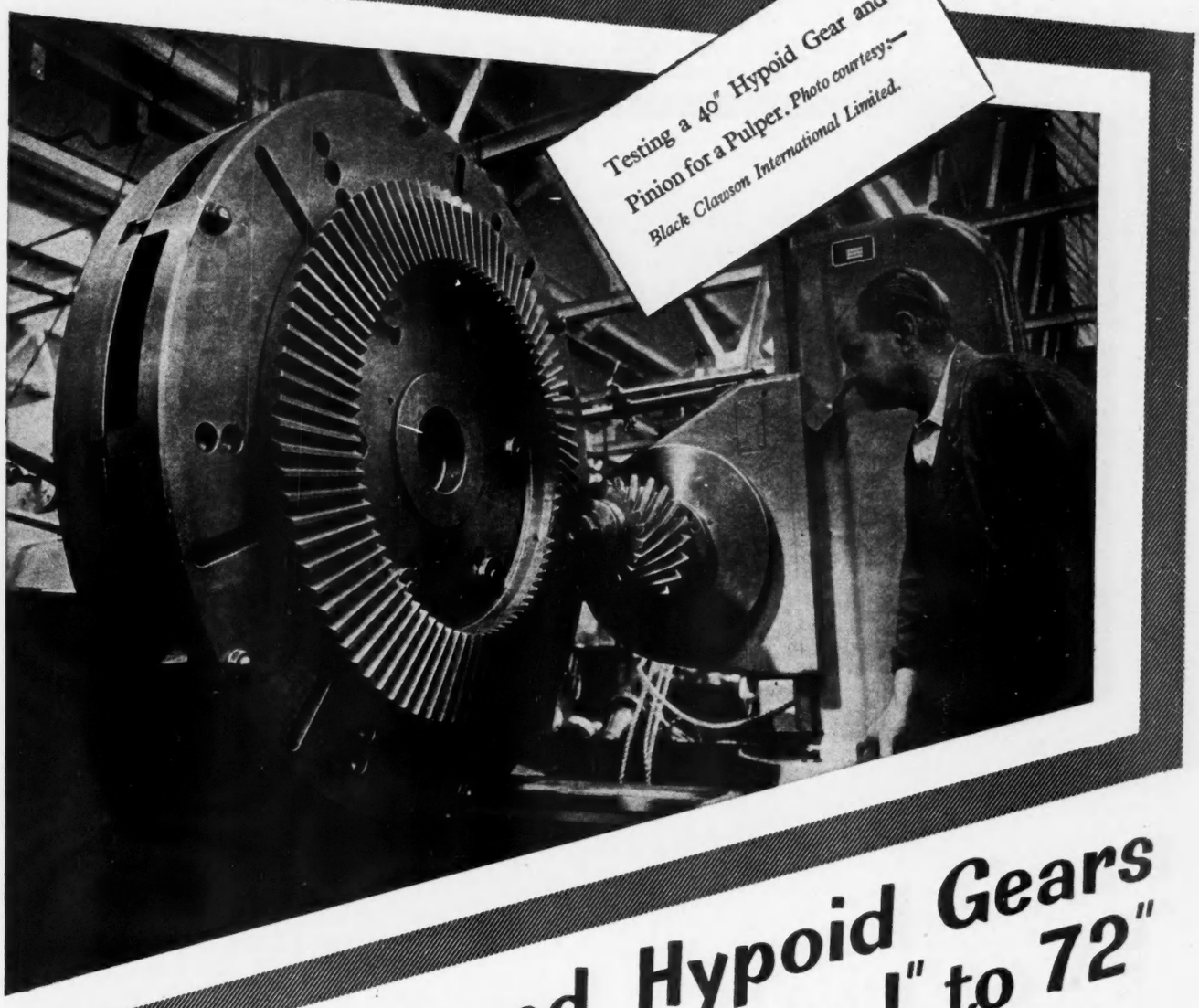

Testing a 40" Hypoid Gear and Pinion for a Pulper. *Photo courtesy:— Black Clawson International Limited.*

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Aeroflex

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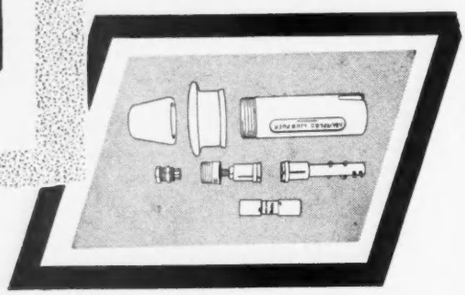
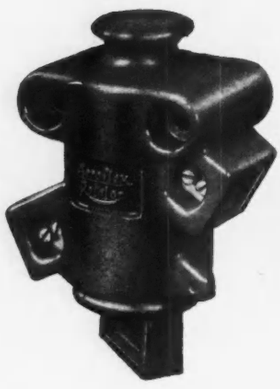
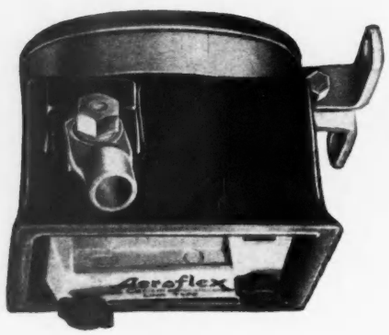
The subject is fully dealt with in our publication No. AL2.



OVERHEAD LINE FUSES

The illustration shows examples from a considerable range of overhead line fuses to suit different situations:—on the left an Aeroflex 60 amp. Rotaloc line fuse is shown, suitable for securing to the cross bar of a line support, and having an adaptable fuse handle carrying an Aeroflex high breaking capacity 60 amp. ADS type rewireable cartridge fuse-link. The right hand illustration shows a 200 amp. porcelain enclosed line fuse, embodying Link Type handle with Aeroflex Ceram high breaking capacity rewireable cartridge fuse-link.





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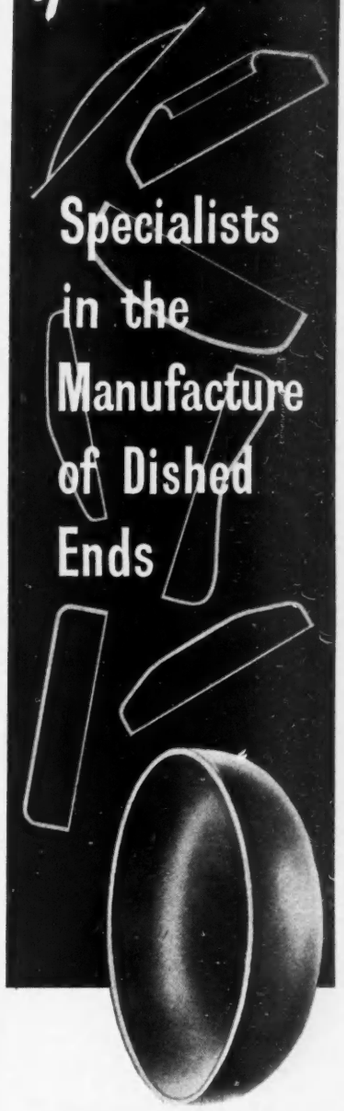

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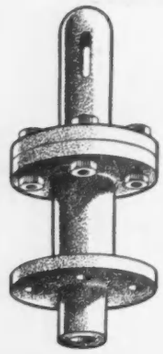

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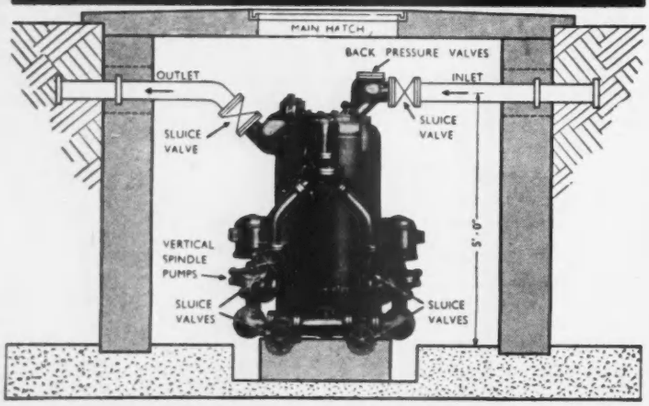

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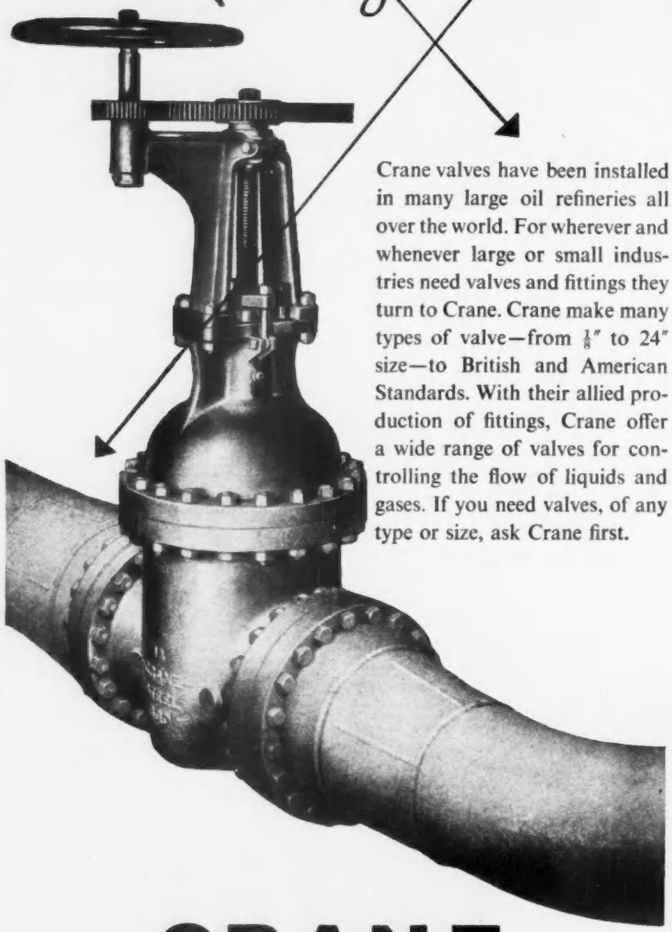

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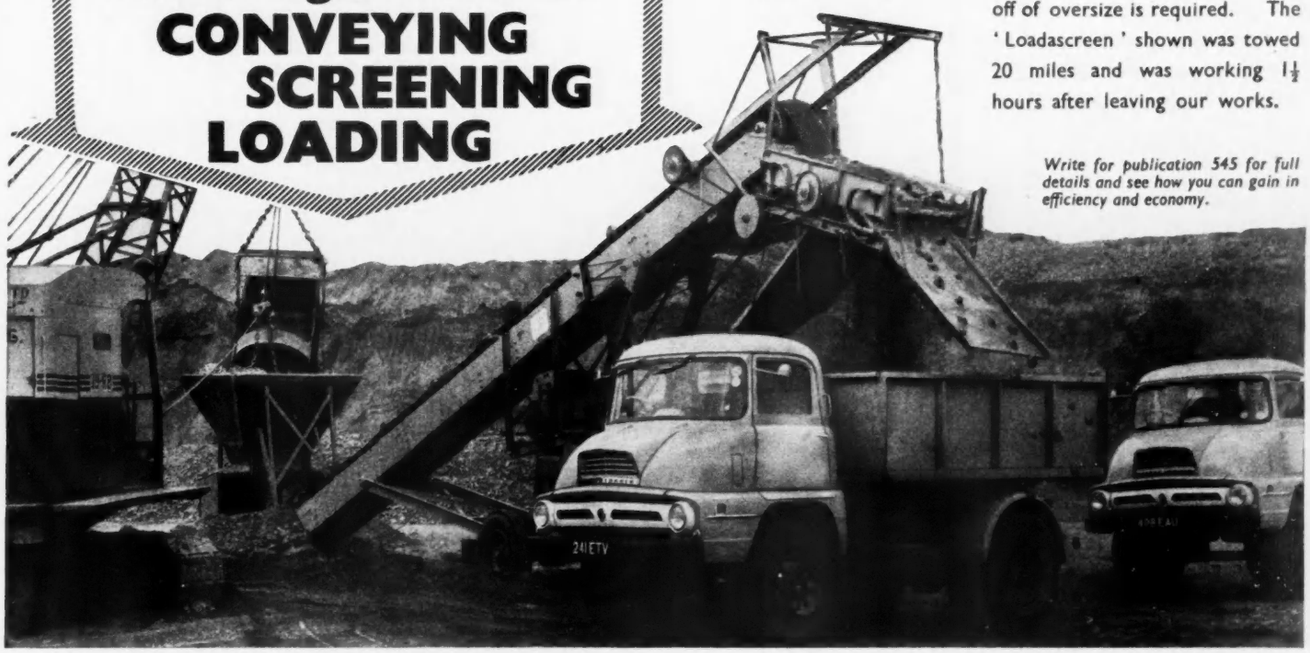

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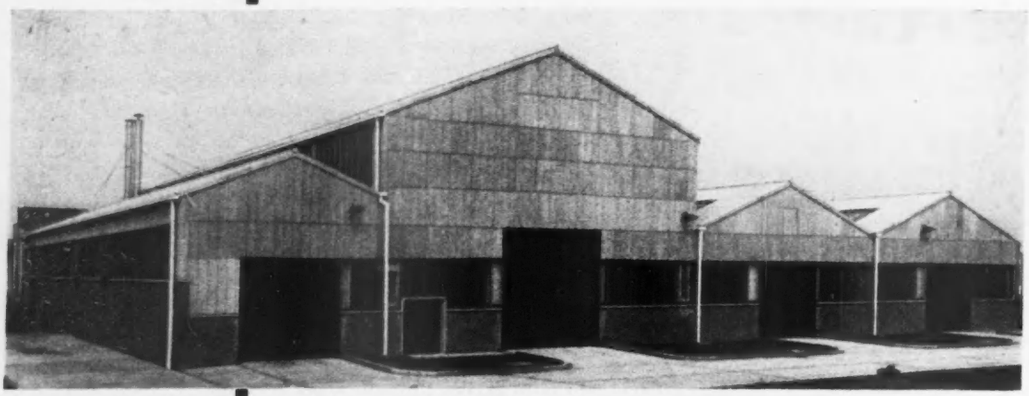

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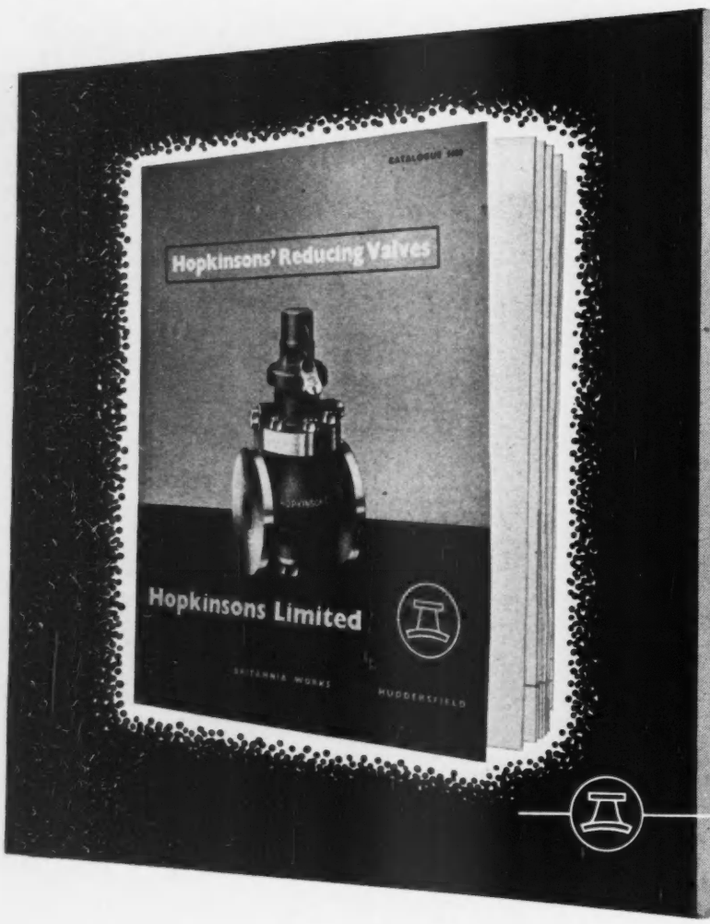

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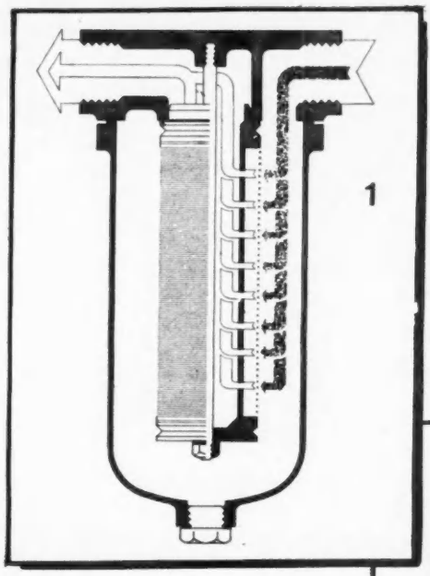


AUTO-KLEAN LOLOS (1)

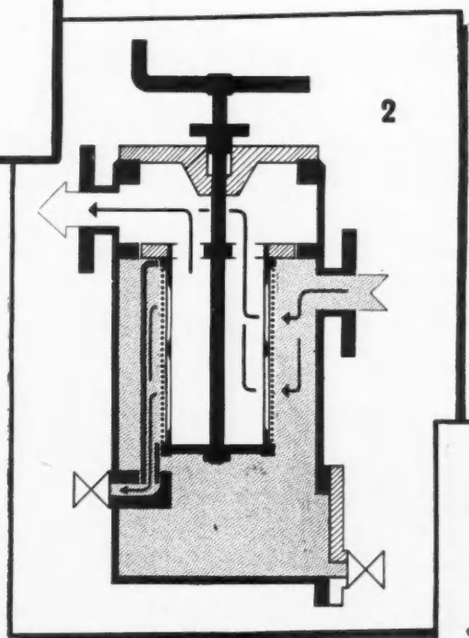
This is a range of filters incorporating wire-wound elements designed for ultra fine filtration of low to medium viscosity fluids under pressure.

Principle: A ribbed cylindrical former is screw cut, and a continuous monel or stainless steel wire is tightly wound into the grooves. By altering the pitch and/or the diameter of the wire defined alterations of mesh can be accomplished. LOLOS L.F. filters have a fabric sleeve fitted over a fine mesh wire-wound element.

Advantages: AUTO-KLEAN LOLOS filters ensure ultra fine filtration *with negligible pressure loss.* Their robust construction remains non-collapsible under extreme pressures, requiring practically no maintenance. Also important is its small lightweight construction.

Data: Working pressures can be arranged up to 2,000 lb/sq.in. Also included in the range are duplex and multi-element designs.

Typical Applications: Hydraulics; fuel and lubrication systems in air, sea and land transport, cooling circuits; distilleries; irrigation lines; washing and bottling plants, etc.



AUTO-KLEAN FLUSHFLO (2)

This is a range of self-cleaning filters specifically designed for continuous operation in the cooling and lubricating systems of heavy machinery.

Principle: Sludge collected by a wire-wound element is dislodged by reverse flow, while the filter element is electrically or manually turned. In contact with the wire element is a spring-loaded slotted tube which acts simultaneously as 'scraper' and discharge passage.

Advantages: The FLUSHFLO is completely self-cleaning while in service without interruption of liquid flow. It ensures fine, positive full-flow filtration with very low pressure losses. And, because the sludge is removed automatically without dismantling, its use leads to reduced maintenance costs. FLUSHFLO filters are also noted for their large capacities relative to size.

Data: Capacities and mesh dimensions fully tabulated in Auto-Klean literature. Quotations on request for processes and capacities not already covered.

Typical Applications: Large scale oil and water cooling circuits; hydraulics; washing plants; water treatment plants; machine lubrication, etc.

AUTO-KLEAN MICOM (3)

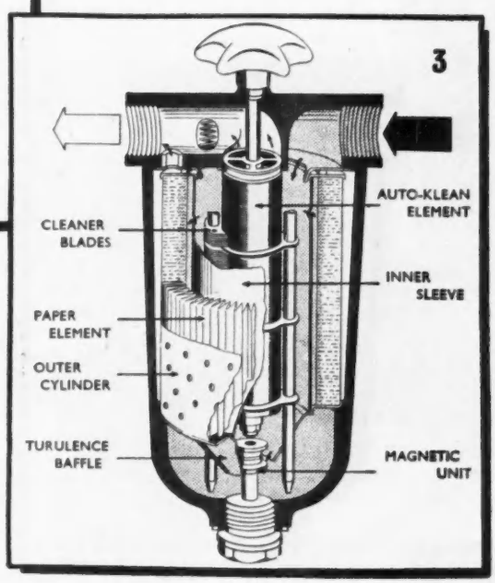
The MICOM combines the advantages of paper as a clarifier with the efficient characteristics of an Auto-Klean, self-cleaning, plate-type element in a full flow filter.

Principle: The greater part of the fluid passes through the plate-type element, while the remainder is filtered by the paper. *The whole of the filtered liquid passes to the outlet side of filter,* thereby giving the maximum protection to the system. A magnetic unit is also incorporated as additional protection against micronic ferrous particles.

Advantages: Positive filtration is guaranteed despite build-up on paper element; paper cannot collapse through choking and therefore its lifetime is increased; constant pressure is maintained as build-up on paper increases . . . while the plate-type filter can be automatically cleaned by turn of the handle—without dismantling. Also important is the low pressure loss and small, lightweight construction of the MICOM.

Data: Working pressures up to 50 lb./sq.in. Can be supplied with ratchet gear for link drive from moving mechanism.

Typical Applications: Ideal for diesel engine lubrication systems of the medium horse-power range and other similar recirculatory applications.



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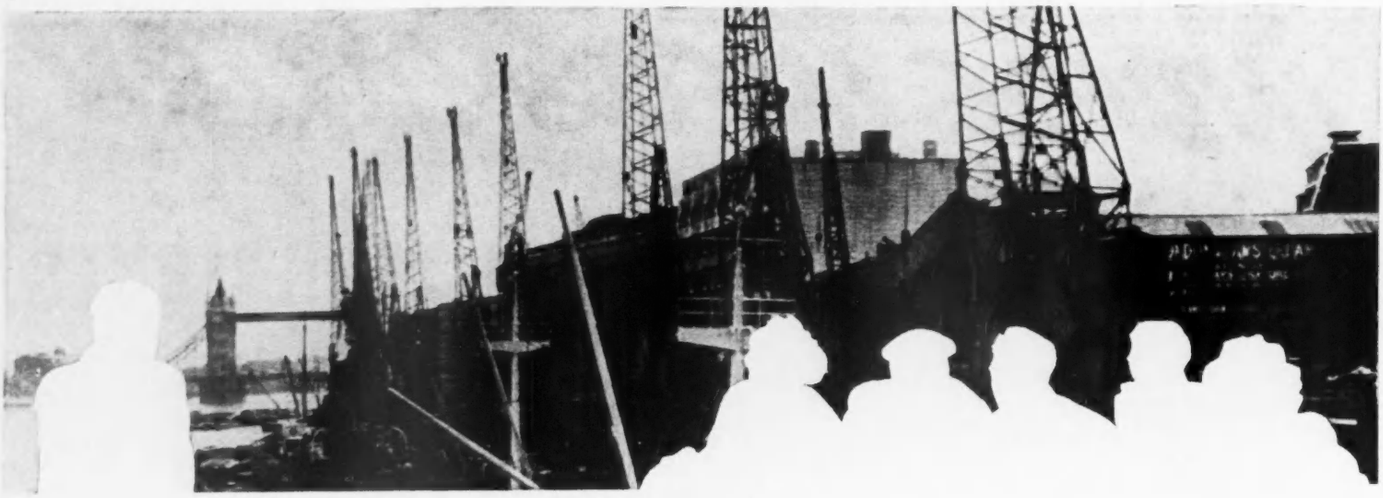

watching the cranes go high

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Wherever the scene is set observant spectators will notice that the ships with the quickest turn-round are **served by Stothert and Pitt cranes.**

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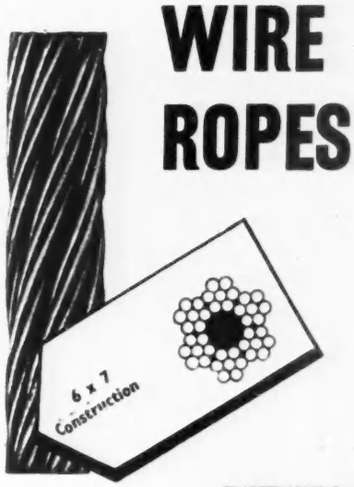

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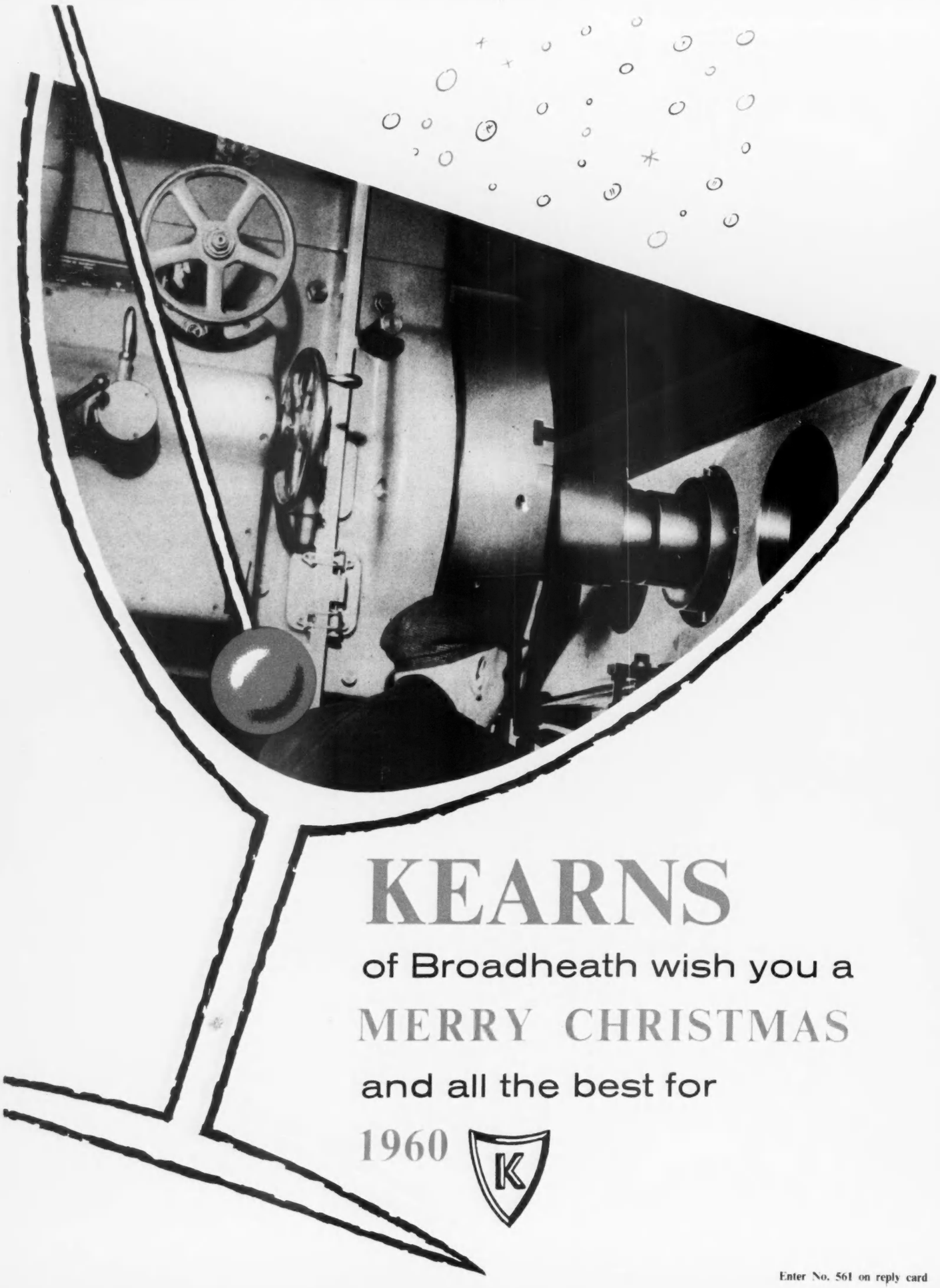

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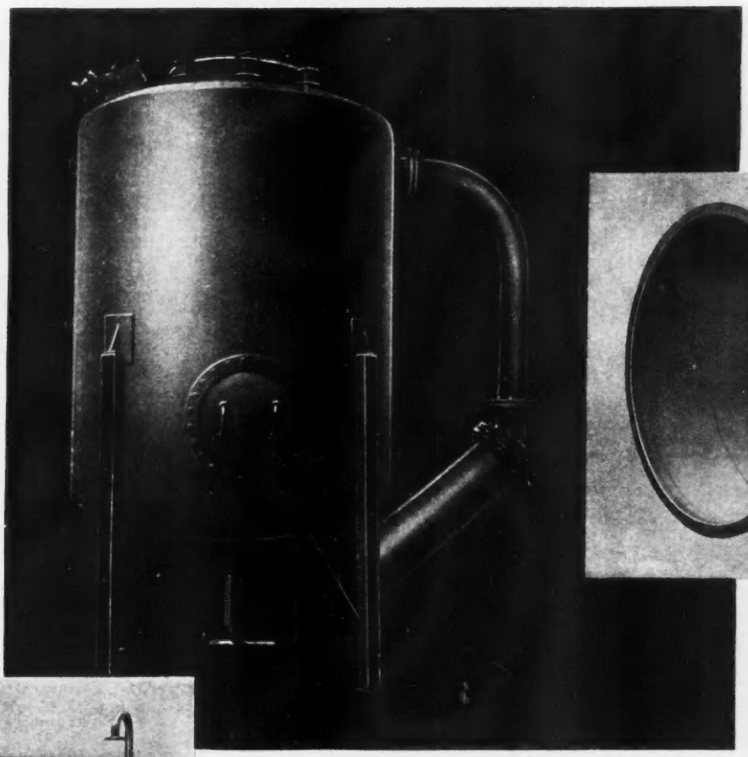

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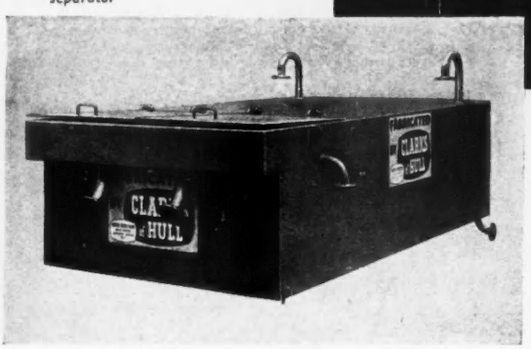

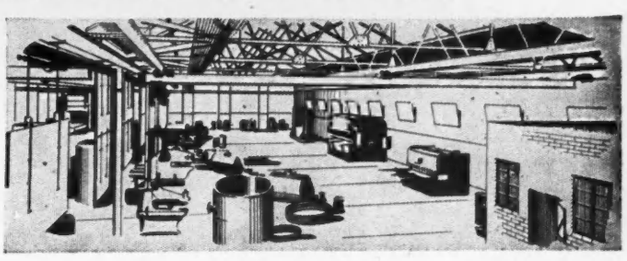

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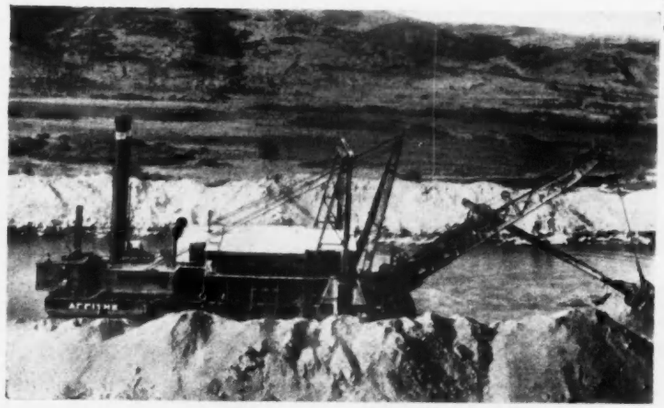

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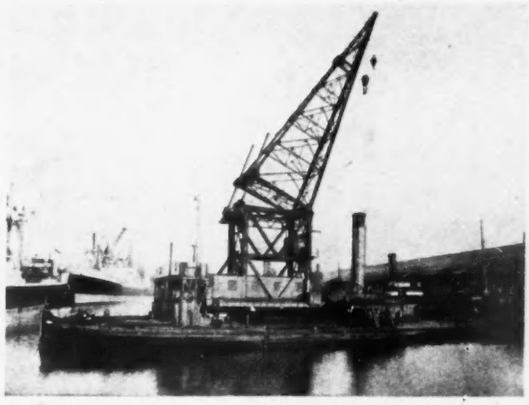

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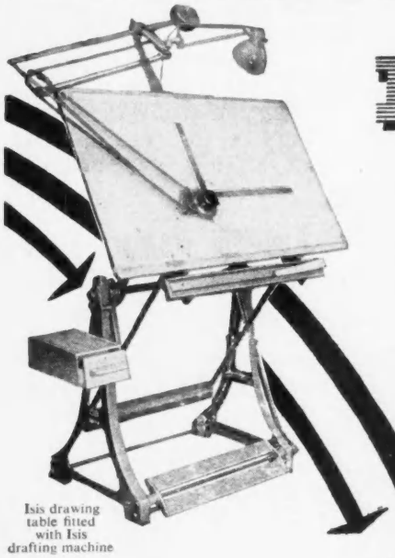

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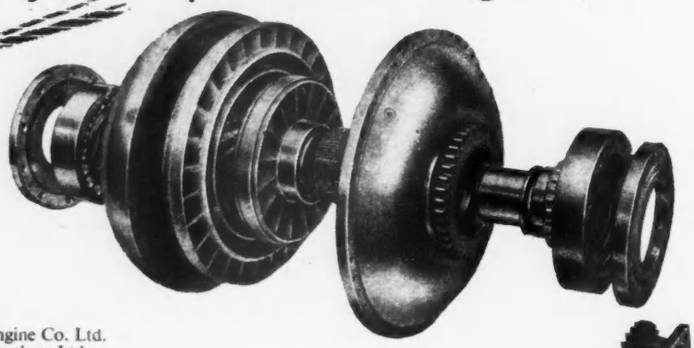

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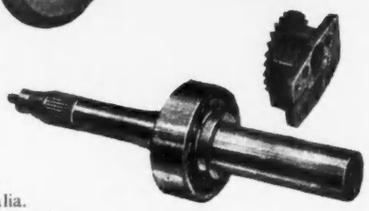

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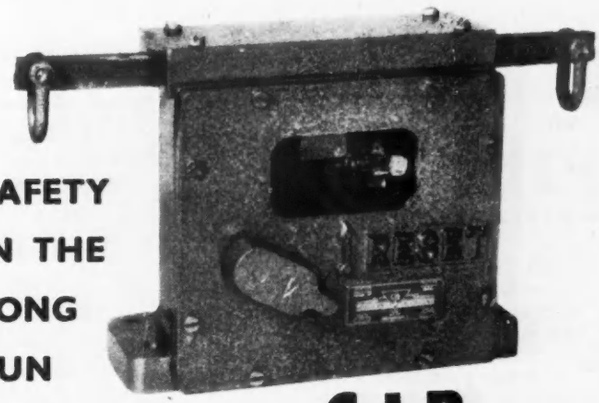

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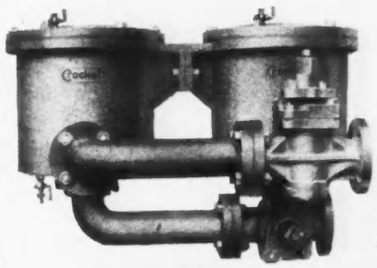

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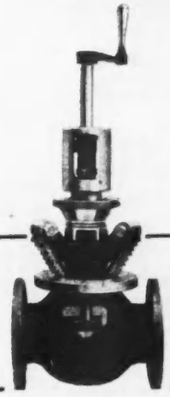

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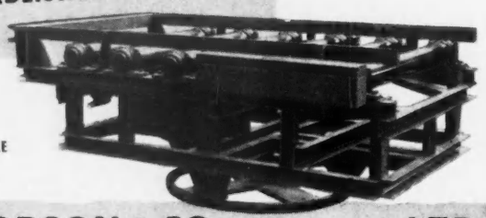

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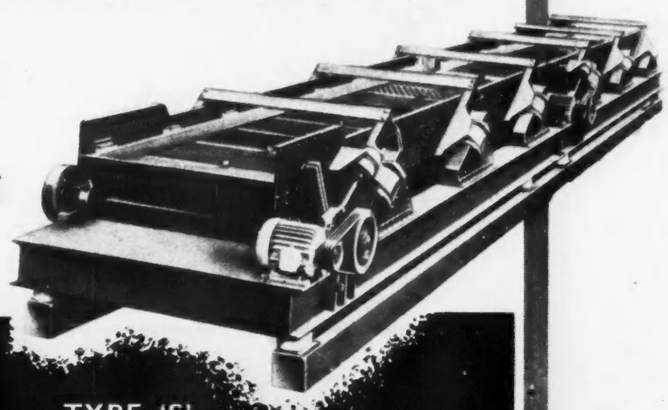

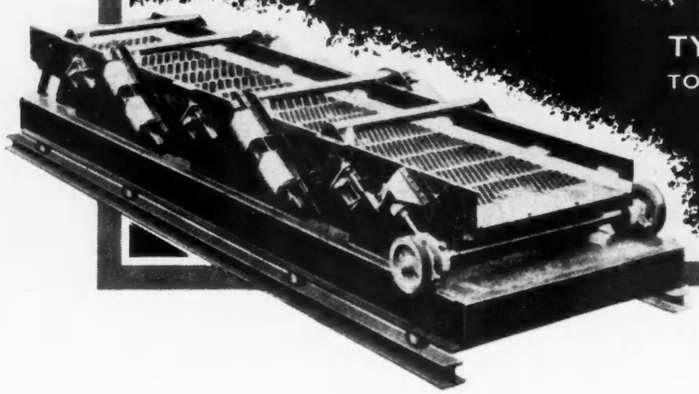

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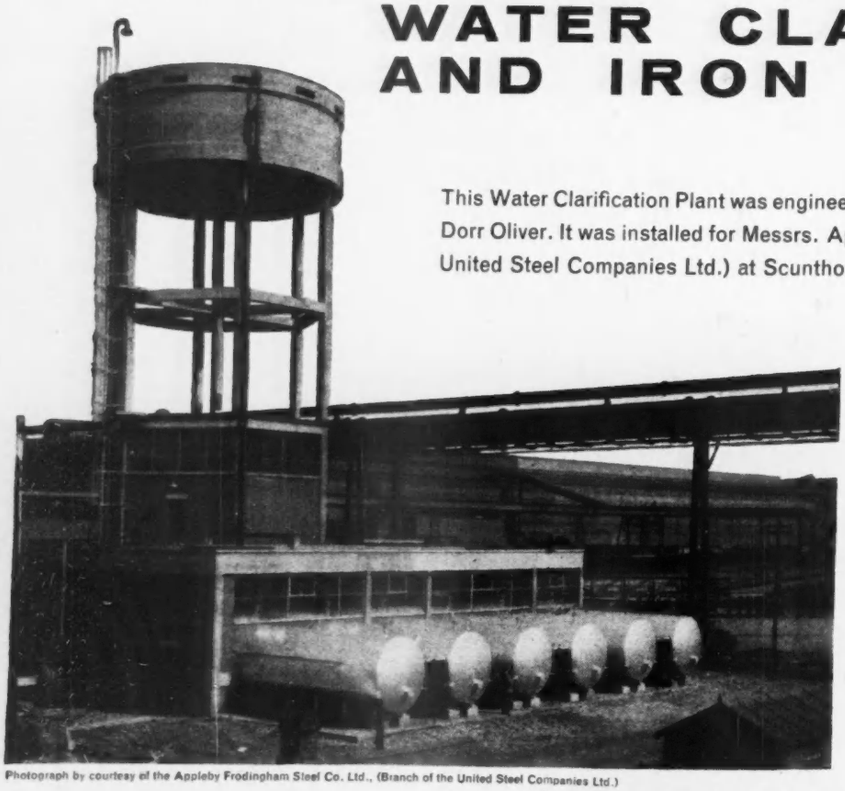
WATER CLARIFICATION AND IRON RECOVERY



This Water Clarification Plant was engineered by Lodge-Cottrell in collaboration with Messrs. Dorr Oliver. It was installed for Messrs. Appleby-Frodingham Steel Company (Branch of the United Steel Companies Ltd.) at Scunthorpe, and enables them to re-cycle the rolling-mill water. A large part of the total flow is cleaned through sand filters to leave approximately 1 part per million of solids. Secondary filtration of the thick slurry, taken off as underflow from the Clarifier, is also provided.

Another Filtration Plant, similarly engineered, has been in operation for three years at the Ebbw Vale Works of Richard Thomas and Baldwins Ltd. It recovers solids with an iron content of about 35%.

At the Steel Company of Wales' Works a Filter Plant to recover solids in cake form, with a water content of about 14% is now nearing completion.

Photograph by courtesy of the Appleby Frodingham Steel Co. Ltd., (Branch of the United Steel Companies Ltd.)

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THE ENGINEER

No. 5421 DECEMBER 18, 1959 VOL. 208

SCIENTIFIC AND ENGINEERING MANPOWER

Recently doubts have been expressed as to whether there really exists the shortage of engineers and scientists that is supposed to exist and which the Committee on Scientific Manpower of the Advisory Council on Scientific Policy was supposed to have proved to exist in its 1956 Report. A new report relating to conditions in 1959 lies before us as we write and it makes it clearer how the doubts may have arisen. For whereas forecasts of requirements by a variety of employers showed that there ought to have been an increase in the number of scientists and engineers in employment of 27·2 per cent between 1956 and 1959 in fact the percentage increase only amounted to 19·7. It is quite wrong, however, to assume that the shortfall indicates a substantial error in forecasting. For the forecast was drawn up on the basis that enough people would be available for employment. To quote from the Report " If all employers had been able to fill their current vacancies the total number employed at the beginning of 1959 would have exceeded the forecasts of requirements made in 1956." In fact the reader is left to conclude that a shortage of engineers and scientists does exist.

The whole of the story is not told by the figures we have quoted. They conceal the fact that in several fields forecasts proved wide of the actual out-turn. In the chemical industry and allied trades for example the actual increase in the number of engineers and scientists employed was 45·4 per cent against a forecast of 20·4 per cent. The number now employed reaches over 12,100. In a group of mainly engineering industries now employing over 10,000 engineers and scientists, the increase amounted to 51·6 per cent as compared with a forecast of 38·3 per cent. Changes in defence policy, no doubt, partly account for the fact that the actual increase in the aircraft industry amounted to only 40·3 per cent as compared to a forecast of 54·7, though unfilled vacancies are higher in this industry than in any other of comparable importance. The most striking figure relates to electrical engineering in which the actual increase was only 9·7 per cent as against a forecast of 43·2 per cent. That remarkable shortfall perhaps reflects the influence of the slight recession in trade between 1956 and 1959 ; and it may also have been partly brought about by disappointment of the apparently bright prospects of gaining orders in the nuclear power field which seemed to rule in 1956. It should be noted, however, that to a considerable extent it can be explained by some inability of the industry to attract sufficient applicants ; for with 13,380 engineers and scientists employed in 1959 unfilled vacancies totalled 1687. Amongst other figures of interest in a table showing the situation in a number of industries there are the surprising entries against " shipbuilding and ship repairing and marine engineering." A 10·7 per cent increase in numbers of engineers and scientists employed was forecast. The actual increase was 60 per cent and a substantial number of vacancies remained unfilled ! According to the Report the wide variation from the forecasts in a number of industries is " most likely " to be explained by " the varying economic experience of different industries during the period, difficulties in recruiting highly specialised scientists and engineers, and the varying attractiveness of industries competing for an inadequate supply of scientists and engineers." Our impression is that it is not easy to correlate these explanations entirely satisfactorily with the experiences of industry. If the Committee can find the time it would be interesting to inquire more closely into the situation. It may well be, for example, that in certain industries, doing temporarily less well, not very much real effort was exerted to fill existing vacancies, with the consequent creation of an erroneous impression of shortage of supply.

Forecasting, the Committee states that employers appear to be aiming at employing some 38,700 more scientists and engineers by 1962, a total increase of 22 per cent. Adding in another 14,000 to cover losses due to retirements, deaths and migration, a total of 52,700 is reached. Forecasts of supply indicate that the number of scientists and engineers qualifying for the first time will increase from 14,600 in 1958 to 18,500 in 1961 so that the Committee thinks it can count on about 47,500 newly qualified people becoming available for employment during the next three years, a slight shortfall as against estimated demand. The general situation is therefore not unsatisfactory. But a comment does seem called for. It is that though there is a rough correlation between vacancies and qualified people becoming available to fill them there is no guarantee that there is as close a correlation between the numbers qualifying in any given science or technology and the demand for their services within that science or technology. There does seem to be evidence, for example, in the Report itself that more biologists are being trained than can find employment as biologists. It may well be that some such maladjustment has created some impression among young engineers that the shortage of engineers claimed to exist does not in fact exist. Taking into account the shortfall in the employment of electrical engineers, for instance, it can be asked whether too many may be under training in that particular field ; whereas, perhaps, too few are being trained in civil and mechanical engineering. It would require a good deal of digging to derive the necessary statistics to answer such queries from the Committee's Report. May we hope for some greater clarity on the matter next time ?

ROAD RESEARCH

It is only in the past year or so that the Government's programme of road construction has got under way on an appreciable scale. One very obvious accompaniment to it has been a vastly increased clamour—in the House of Commons, in the press, and so on—about all matters relating to roads, their construction, and road safety. The publication of the D.S.I.R.'s report on road research for 1958, brings these topics back to earth once more,

with a factual survey of a range of problems in the two fields covered, namely " traffic and safety " and " materials and methods of construction." The Road Research Board's consistent policy over the past years will, however, be evident, and if we regret the neglect with which its advice was sometimes treated in the past, we can hope that, with the changing climate of public opinion, more rapid progress lies ahead in the application of the new knowledge which the Road Research Laboratory is acquiring.

In the years preceding the start of the road programme, we were assured that everything possible was being done in the way of preparation to make things easier when the nation's economy permitted a start on new construction. Now that this time has arrived, it is painfully evident how little preparation was in fact achieved, and how much is still to be learned or ascertained. The Road Research Laboratory's work is proving a major factor in progress of this kind.

Promising research is also being carried out on various aspects of road accidents. Attention is given in the report to skidding and skid prevention, vehicle inspection (the Laboratory's investigations were summarised in a paper before the " Mechanicals " by Grime and Lister), " on-the-spot " accident investigations, the analysis of accident statistics, and street lighting and traffic lights as they affect accident rates. It is valuable to have statistical evidence on accidents, and to have available facts such as those given for motor-cycles, where the risk of death to the driver is over twenty times greater than in the case of a four-wheeled vehicle, and the risk of injury fifteen times greater. But promising though these researches are, they fall short in some respects of the desirable " threshold " of social usefulness, namely, leading to positive recommendations which result in reduction of accidents. Study of the performance of vehicles in relation to safety, and of desirable ergonomic standards of measurement for vehicles is largely neglected. The designer of a vehicle needs an answer to the question " How do I design a vehicle to reduce the possibility of accidents to a minimum, and to behave in the safest possible manner, should an accident occur ? " Likewise, the operator needs to know how to choose the safest vehicle for the duty he has in mind. Objective standards are needed in these matters. Many accidents are attributable to unsatisfactory road design. If this is remedied, there still remains a challengingly high accident rate.

" ASTA " COMES OF AGE

This year the Association of Short-Circuit Testing Authorities (ASTA) is celebrating its twenty-first birthday. In an individual this event usually signifies the attainment of an age of responsibility and discretion, with the promise of growth to full maturity in due course. But in ASTA, despite its tender years, all these qualities are already well developed. Perhaps this is because the Association has had to grow up the hard way, unpampered, and learning from experience, as can be deduced from the excellent booklet *Twenty-First Anniversary* which sets out the origin, history, status and aims of the Association.

In a sense ASTA started out as a compromise, for the original intention had been to establish an independent organisation which would become the accepted national authority for assigning safe and economic ratings for circuit breakers, for setting test standards and for carrying out certification tests to these standards. Despite the persistent efforts of a number of engineers the idea had to be abandoned. Instead individual switchgear manufacturers had to face the large capital cost of building their own testing stations. When these independent stations came into being during the 1930s they created as many problems as they solved. For the switchgear user had no means of correlating the performance of different circuit breakers tested under different conditions in the various testing stations. In these circumstances, at a time of rapid progress in the art of switching, it became impossible to make a fair assessment of the merits of competitive designs of circuit breakers. In the absence of any outside and independent authority, then, the only practical solution was to devise some form of collaboration between the separate testing stations. Since these stations were effectively in competition with each other the proposition that they should co-operate by seeking agreement on matters like testing methods and presentation of results, might have seemed hopeless. Nevertheless enlightened self-interest and mutual advantage smoothed out many of the difficulties. The scheme has worked and worked well.

To-day The Association of Short-Circuit Testing Authorities is recognised in Britain as the authoritative body for short-circuit testing and the certification of large circuit breakers, reactors and fuses. In addition, mainly through the knowledge accumulated from countless testing programmes, ASTA has made a distinctive contribution to research and development. For example, as mentioned on page 828 of this issue, methods developed by ASTA for measuring, assessing and specifying the rate of rise of restriking voltage in tests on circuit breakers have been adopted in B.S.I. standards and those of the International Electrotechnical Commission. Of course much remains to be done on the level of international co-operation. A beginning has been made, on a limited scale, between ASTA in Great Britain and KEMA, the Dutch short-circuit testing authority. What is wanted now is work towards a basis for internationally agreed interpretations of national standards. Aims such as these were touched upon by Colonel B. H. Leeson at ASTA's coming-of-age dinner in London last week. Clearly ASTA has worthy ambitions and is young enough and vigorous enough, we hope, to see them fulfilled !

NOISE ABATEMENT

The Government's decision to set up a committee to investigate the problem of noise is one that will be generally welcomed. The decision was announced on Monday, in the House of Commons, by the Minister of Health, Mr. Walker Smith, who was acting as spokesman for the Minister of Science. The committee, he said, would examine the nature, sources and effects of the the problem of noise and would be required to advise as to what further measures could be taken to mitigate it. The announcement was made in reply to a question by Mr. Nabarro who mentioned the " growing damage to human efficiency, the bad effects upon health, and the incursions into leisure caused by unregulated noise." He claimed that, with each scientific advance, the impact of noise upon the human constitution was growing and he presented a short list of the kinds of noises which he urged should be examined. These included noises from jet aircraft, exhausts of sports cars and motor-cycles, pile-driving steam hammers, pneumatic drills and uninsulated industrial machine shops. The Noise Abatement Society, which was formed earlier this year, could undoubtedly add to Mr. Nabarro's list whilst quietly rejoicing that an initial step is to be taken towards the elimination of " all excessive and unnecessary noise from all sources."

But in applauding the Government's intention to

appoint a committee on noise abatement and in expressing the hope that the endeavours of the Noise Abatement Society may prosper, we realise that a satisfactory solution will not be easily reached. Unquestionably, the present is a noisy age and the rising generation is not very much perturbed on that account. We know, for instance, of more than one example of maths. homework being regularly tackled and completed to the strains of jazz music provided by a record player ! And at prescribed intervals on press day, type-setting, founding and machining are conducted in our printing works to the accompaniment of radio " Music while you work." These, we must suppose, are noises that stimulate and improve productivity, though to us, we confess, they fit Mr. Nabarro's definition of " damage to human efficiency." Perhaps it has to be acknowledged, at the outset, that noise is an irritant which affects the middle-aged and elderly far more than it does those who are in the bloom of youth ! Whether that is so or not, there is much to be said for a serious attempt to regulate and control excessive noise. Engineers and scientists are obviously the people best fitted to undertake the task. They have achieved, and are achieving, commendable success in ridding the atmosphere of pollution. They will bring further benefit to mankind if they succeed in eliminating the noises that annoy.

TRAFFIC ENGINEERING

The effect—the good effect—of the Civils' liberal policy towards the new foundling of Traffic Engineering has been very apparent at the two discussion meetings of the Study Group so far held. With membership generously not limited to members of the Institution, the attendance has been not only well variegated but relatively enormous—for one Group of one Institution. Then the decision to rate the discussions informal has mitigated a little the restraint very properly felt by speakers in such surroundings, and debate has waxed accordingly. Finally, to ensure that debate would be sustained, there was the choice of that " pace maker," Mr. H. J. B. Harding as Chairman for the first meeting, followed by Sir Herbert Manzoni for the second ; both closed their meetings, reluctantly, only after two and a half hours ; if ever discussion meetings were a success, these were. This augurs well, and we compliment the Institution of Civil Engineers on giving the Group a first-class start.

Can we already, after only two meetings, discern a trend, a path which British traffic engineering will take ? Well, it may be an indication that the liberal approach of the Civils to the study of the subject was matched closely, in the approach to the subject itself, by many of the speakers at the meetings, particularly in the matter of standards emanating from the Ministry of Transport. We hasten to mediate—or try to mediate—by pointing out that officially such standards are for no more than guidance ; but we sense already that only a liberal interpretation of them will satisfy the British temperament in traffic engineers. The minutiæ of traffic engineering can be a science, but the whole must be an art. Our artists in that department will no doubt always find themselves on a tight financial rein ; no other reins, please, is a note sounding strongly in the Traffic Engineering Study Group.

INTERNAL STANDARDS

Although it has for some time been increasingly recognised in industry that the adoption of a standards system within a company's organisation is of economic importance the value of internal standards is still often ignored by many firms. Indeed, we once heard internal company standards referred to as " common-sense economics which are accepted with reluctance and ignored all too often by those who would benefit most from them." This was a somewhat sweeping statement but, as a visit to the stores in most works would show, is not without a large element of truth. In the case of simple components such as bolts and screws how often does one find a variety of heads and intermediate lengths—many of which could be eliminated without detriment to finished products had a designer used internal standards ? Similarly in the case of drawings, forms and stationery, there are frequently used a variety of sizes, which needlessly complicate filing systems, where the adoption of a few standard sizes would adequately cover most requirements. These two simple examples could be amplified in many organisations.

The economic advantages of adopting a system of internal standards by firms of all sizes are obvious and for this reason the recently issued booklet " The Operation of a Company Standards Department " by the British Standards Institution is well worth the attention of every industrial concern. This booklet is designed to provide a concise guide to the principles and practice of applying standards in an individual firm. It has been written with the assistance of a small group of standards engineers engaged in big manufacturing concerns and process industries, who are well qualified to deal with the subject. A primary object of the new publication is to help those already concerned with internal standards organisation and newly appointed standards engineers. In describing how to lay the foundations for an effective and economic internal standardisation organisation the B.S.I. has provided in its booklet much matter which will be of interest to concerns already operating a scheme and of value to those which would benefit from the introduction of internal standards.

The Engineer—100 Years Ago (DECEMBER 16, 1859)

" THE VICTORIA BRIDGE "

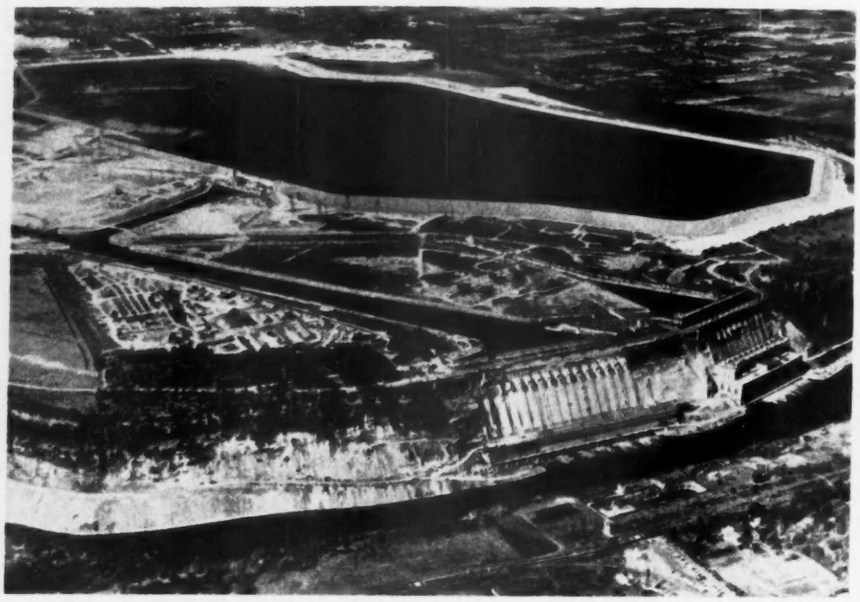
" It is upwards of six years since the late Mr. Robert Stephenson visited Canada, for the purpose of determining the general plan of a railway bridge to cross the river St. Lawrence at Montreal. His report to the directors of the Grand Trunk Railway Company was accepted, and not long after his return to England he was instructed to proceed with his design. The work thus determined upon was to be the greatest example of engineering construction in the world ; and as such it was completed and brought into use on the 24th ultimo. The Victoria Bridge, thus named at the commencement of its construction, is an iron tubular bridge of 25 spans, covering a clear opening of 6,540 ft., or nearly 1¼ miles, between the abutments. The great river flowing beneath has an exceedingly rapid current, and when the ice, into which its surface is always deeply frozen in winter, breaks up and floats off in the spring, it acquires such an immense momentum, that only the very strongest constructions could stand for a moment in its course. The masonry in the piers and abutments is, therefore, of the most massive character, the stones averaging 10 tons each in weight. The entire masonry, of which there are 3,000,000 cubic ft., is said to have cost about £1,000,000, or £40,000 for each pier . . . .

" The Victoria Bridge, grand as it unquestionably is, is an extravagant structure, and as such is in singularly inappropriate ownership. The Grand Trunk Company never could, and never can afford, such a work, especially whilst one, practically as strong, and every way as useful, might have been erected for two-thirds the cost, which, even then, would have been enormous."

St. Lawrence River Development

XII—The Niagara River and the Welland Canal

This series has now traced the course of the St. Lawrence Seaway and its associated power stations from Montreal to Lake Ontario. The Welland Ship Canal, which completes the navigation facilities leading to the Great Lakes, is already well known, but is briefly described here to complete our account of the Seaway scheme. We also review the Niagara River power stations on the Canadian side, describing the reversible pump/turbines of the pumped storage scheme.



THE main constructional works—both for power and navigation—which have had to be built to complete the St. Lawrence Seaway have now all been described. It should be remembered, however, that the Seaway scheme depended partly on existing canals along the St. Lawrence, in particular the enormous Beauharnois power canal, and the Welland Ship Canal. The most difficult obstacle to opening the Great Lakes to ocean ships was undoubtedly the difference in level of 326ft between Lake Ontario and Lake Erie. But here the complete Seaway was anticipated by a quarter of a century because of the growth of shipping on the Great Lakes. The Welland Ship Canal, which was completed in 1932, has lock and channel dimensions which are standard with the other Seaway works downstream from Lake Ontario. Further works were necessary to bring the Welland Canal up to the required standard of 27ft depth throughout its length, but these works were in the nature of minor modifications rather than major changes. Even so, the cost of these new works has been about 25,000,000 dollars.

The Welland Ship Canal is 27½ miles long; its route starts at Port Weller on Lake Ontario, and follows a course approximately parallel to the Niagara, to Port Colborne on Lake Erie. The locks, which are grouped towards the northern (Lake Ontario) end of the canal, have practically the same dimensions as the seven Seaway locks further downstream, each one being 80ft in width with a depth of 30ft, the ruling useful length being 765ft. The canal is 200ft wide at the bottom, and 310ft at the water line, with 120ft overhead clearance. Experience gained during the construction and operation of the Welland Canal has been one of the factors which influenced the design of the Canadian Seaway works.

There are turning basins at four points along the canal, and three small ports—St. Catherine's, Thorold and Welland—along its length. The eight locks have a total lift of 327ft. The "guard lock" at Humberstone, near Port Colborne, has a lift of 2ft to 11ft, depending on the wind which affects the Lake Erie levels. There are then seven main locks each with lifts of 44ft to 48ft. There is a twin flight of three locks near Thorold with a total lift of 139·5ft. At the foot of these locks is the hydro-electric station which generates power for the canal's locks and movable bridges.

The canal passes through a well-populated farming area. It is spanned by six railway bridges and fourteen highway bridges, as well as electric power lines, and there are numerous underwater crossings of services of various kinds. The canal is usually open from April 1 to the middle of December.

When opened, the Welland Canal was considered to be one of the greatest constructional feats of its time. The first world war and economic depression both hindered its completion and, unlike the Seaway, it took around twenty years to complete. Its capital cost was 132 million dollars. Constructional quantities may be of interest in comparison with those already given for the Seaway: excavation totalled 62,000,000 cubic yards, embankments 5,000,000 and concrete 3,600,000. The twin flight of three locks was considered especially noteworthy, and was compared with the Gatun locks of the Panama Canal, which it exceeded in its height of lift. A normal passage through the canal takes about eight hours, the twin locks allowing simultaneous passage up and down, thus obviating delay at this critical section.

New Works on the Welland Canal

The new works now completed as part of the Seaway scheme were grouped into six contracts, three for excavation and three for dredging. Twenty-seven foot navigation was already provided at the locks, and over a total length of 17 miles of the canal, prior to these works; it is now extended over the entire canal, which thus conforms to the general Seaway standards. These works were under the direction of the St. Lawrence Seaway Authority, the contracting firms concerned being J. P. Porter Company, Ltd.; McNamara Construction Company, Ltd.; the Canadian Dredge and Dock Company, Ltd.; Russell Construction Company, Ltd.; Swansea Construction Company, Ltd., and Aiken and MacLachlan, Ltd.

One point of interest in this work concerned the protection of locks and structures from damage caused by underwater blasting nearby, when the canal was deepened. The following description is taken from a paper presented in March, 1958, by Mr. W. A. O'Neil.*

"When blasting rock in water, shock pressure waves are set up in the water and can damage nearby structures. To obviate such damage a method is being employed which was developed by the Hydro-Electric Power Commission of Ontario and suggested by Mr. A. Laprairie of Canadian Industries, Ltd., who have patented the process. A screen of air bubbles is placed between the blast and the structure to be protected by placing a 3in diameter perforated pipe horizontally along the bottom of the canal and then pumping 15 cubic feet per minute of air per lineal foot of pipe into the pipe while blasting. The air bubbles in rising to the surface form the screen which absorbs a portion of the energy of the blast transmitted through the water. Tests undertaken by the Commission in connection with a blast set off in the vicinity of one of their power stations at Niagara Falls suggest a pressure reduction of at least 70 to 1.

"To establish the maximum amount of explosive which may be fired at any specific distance from the canal wall, seismic monitoring of the blasts is being carried out. Information obtained when blasting at 25ft from the wall in a depth of 30ft of water indicates that the charge at 50ft should be 20 lb per delay and at 25ft 10 lb per delay. It is known that existing criteria for establishing

* "The Welland Canal," Waterways and Harbour Division, American Society of Civil Engineers.

a safe powder load is not reliable within 50ft of a structure and therefore trial blasts with small charges at 5ft intervals will be monitored. From the data thus obtained a drill pattern and maximum load per delay will be established."

TABLE XII.—*Traffic to End of October on the St. Lawrence Seaway and Welland Canal*

	Upbound	Down-bound	Total
St. Lawrence Seaway (i.e., Montreal to Lake Ontario) :			
Cargo, short tons ...	9,709,900	7,721,600	17,431,500
Percentage increase over 1958 traffic on 14ft canals	128·1	31·8	71·8
Number of ocean vessels through St. Lambert lock	1126	997	2,123
Total number of vessels through St. Lambert lock	3,006	2,855	5,861
Welland Canal :			
Cargo, short tons ...	8,380,200	14,433,200	22,813,400
Percentage increase over 1958	93·7	3·3	24·5
Number of vessels through canal :			
Ocean	992	916	1,908
Total	3,455	3,316	6,771

TRAFFIC CAPACITY

Traffic on the Welland Canal was quite heavy before completion of the Seaway. For example, in 1957 about 22,500,000 tons of cargo was carried through it, the corresponding number of vessels being just over 9000. The latest traffic figures available up to the end of October are given in Table XII for the Seaway and the Welland Canal separately.

In the first few weeks of the Seaway's life last spring, there was some congestion along the route, the worst delays being those reported at the Welland Canal, where ships were taking thirty-six hours to journey through the canal, as against the customary eight hours, and were queueing " like an invasion fleet " to pass through it. Amongst the various problems which the first season's operation of the Seaway have revealed, the limited capacity of the Welland Canal to take shipping in addition to the established Great Lakes traffic appears to be one of the greatest, and is linked with criticism of the inadequacy of U.S. and Canadian port facilities and the attitude of the trade unions controlling Seaway labour, as the three principal drawbacks by those who have commented on the prospects of the Seaway system. From the engineering point of view, it must be remembered that the locks of the Welland Canal are now twenty-seven years old and are thus inferior in performance to the modern locks downstream (see THE ENGINEER, May 10, 1929, for a description of the locks on the Welland Canal). Thus, in spite of the twinned three-flight locks, it appears that the Welland Canal is now the limiting length of the Seaway and duplication of the existing locks will have to be undertaken if appreciable increases in traffic are to be handled. Thus, it is likely that additional construction at the Welland Canal, together with channel and port improvements at the Great Lakes ports, may constitute the next stage of development of the Seaway system.

This winter, a programme of works which will increase the capacity of the Welland Canal is being undertaken and the canal was due to be " unwatered " on December 15. These works involve the construction of some 7000ft of " tie-up walls " which, when completed, will provide tie-up facilities above lock 1 ; at the entrance walls below and above locks 2 and 3, and below and above the guard gate, thus permitting the movement of a ship into a lock, or through the guard gate, immediately the lock is ready to receive it or the guard gate was opened.

The capacity of the canal this year has been thirteen or fourteen lockages each way per day. The new tie-up walls will increase the capacity by about 25 per cent, it is claimed, and they should be ready for the opening of navigation in April, 1960, at an estimated cost of approximately 7,500,000 dollars.

Another study to be made concerns improvement in the hydraulic characteristics of the lock filling and emptying system. The Authority states, however, that it will require considerable time and its immediate effect, if possible, would not compare with the result anticipated from the extension of tie-up walls. A complete review of the maintenance system of the lock equipment is also being undertaken, so that the possibility of breakdowns will be reduced to a minimum. Some changes in the shipping regulations are also contemplated, particularly as regards the equipment required for speedy passage through the locks.

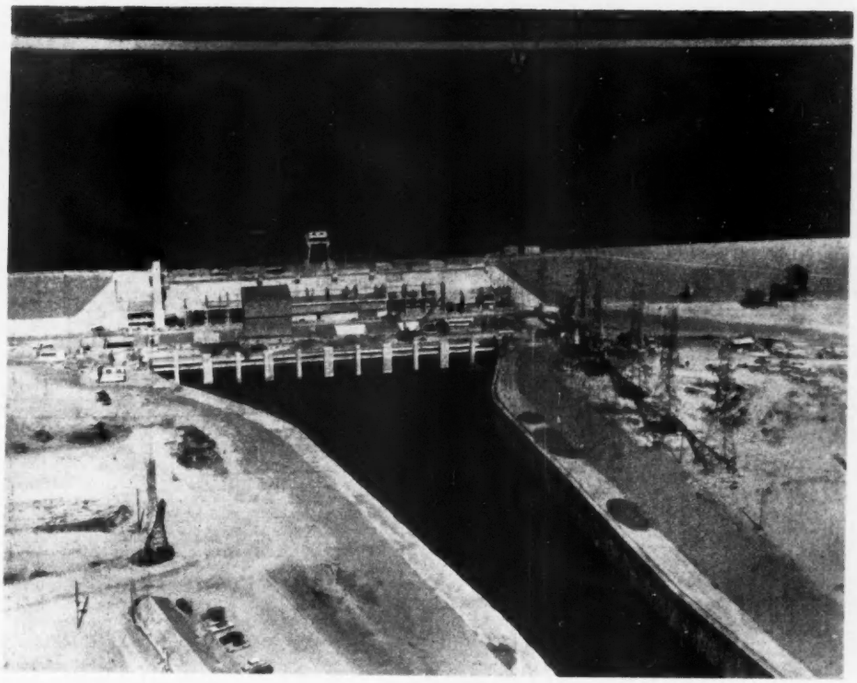


Fig. 42—The Niagara pumping generating station at Queenston and the pumped storage reservoir. Note the semi-outdoor design

THE NIAGARA POWER STATIONS

Complete development of the hydro-electric resources of the Niagara River has been achieved over the past few years on the Canadian side of the river, and will be achieved on the U.S. side as well with the completion of the major scheme now under construction. This complete development depends on the Niagara Treaty of 1950. Under the provision of this treaty, certain " remedial works " were carried out to distribute the flow over the Falls evenly and thus reduce erosion and help to maintain their scenic attraction, and it was stipulated that this flow should not be reduced below 100,000 cusecs during summer days (i.e. 8 a.m. to 10 p.m., April 1 to September 15, and 8 a.m. to 8 p.m., September 16 to 30), nor below 50,000 cusecs at other times. The average " mean monthly " flow from Lake Erie is 207,000 cusecs, with extreme values of 129,500 and 255,800 cusecs.

It is perhaps rather astonishing to engineers accustomed to the scale of British rivers to think in terms of 100,000 cusecs of " compensation water." The figures just given show that, on summer days, about half the total flow is used for power, and at other times about three-quarters. The resulting output of power is so vast that one might be tempted to inquire into how the figure for compensation water was fixed, and if it could have been reduced. The answer can be given quite specifically : the area is the greatest tourist centre for hundreds of miles around, and the number of visitors who come to see the Falls on the Canadian side, and the average amount which each one spends is accurately known. The total tourist income is then quite astronomical when compared with possible additional power revenues. So the natural grandeur of the Falls has a high value in dollars, and paradoxically for the hydro-electric engineer, it pays to waste rather than to utilise sufficient flow to maintain the spectacle, which at half-flow but with " remedial works," is unimpaired and fills the visitor with awe.

Turning now to that proportion of the Niagara which is harnessed to useful ends, and is prevented from dissipating its energies in a panache of spume and thunder, we find that the layout of the principal elements on both the Canadian and U.S. sides follows closely similar lines. Each country's works consist of an intake a mile or two upstream from the Falls with diversion tunnels leading to a main stage of power generation in the Niagara gorge, at power stations on opposite banks of the river about 5 miles down river from the Falls. This length of diversion gives a head of almost 300ft. In addition each scheme has a pumped storage reservoir served by a pumping/generating station situated at the end of the high-level section of the main diversion. The U.S. works will be described by our American editor when they are complete.

But it may be pointed out here that the construction of two such similar schemes facing each other in different countries has aroused no little interest. In particular, the pumped storage schemes—the only ones of

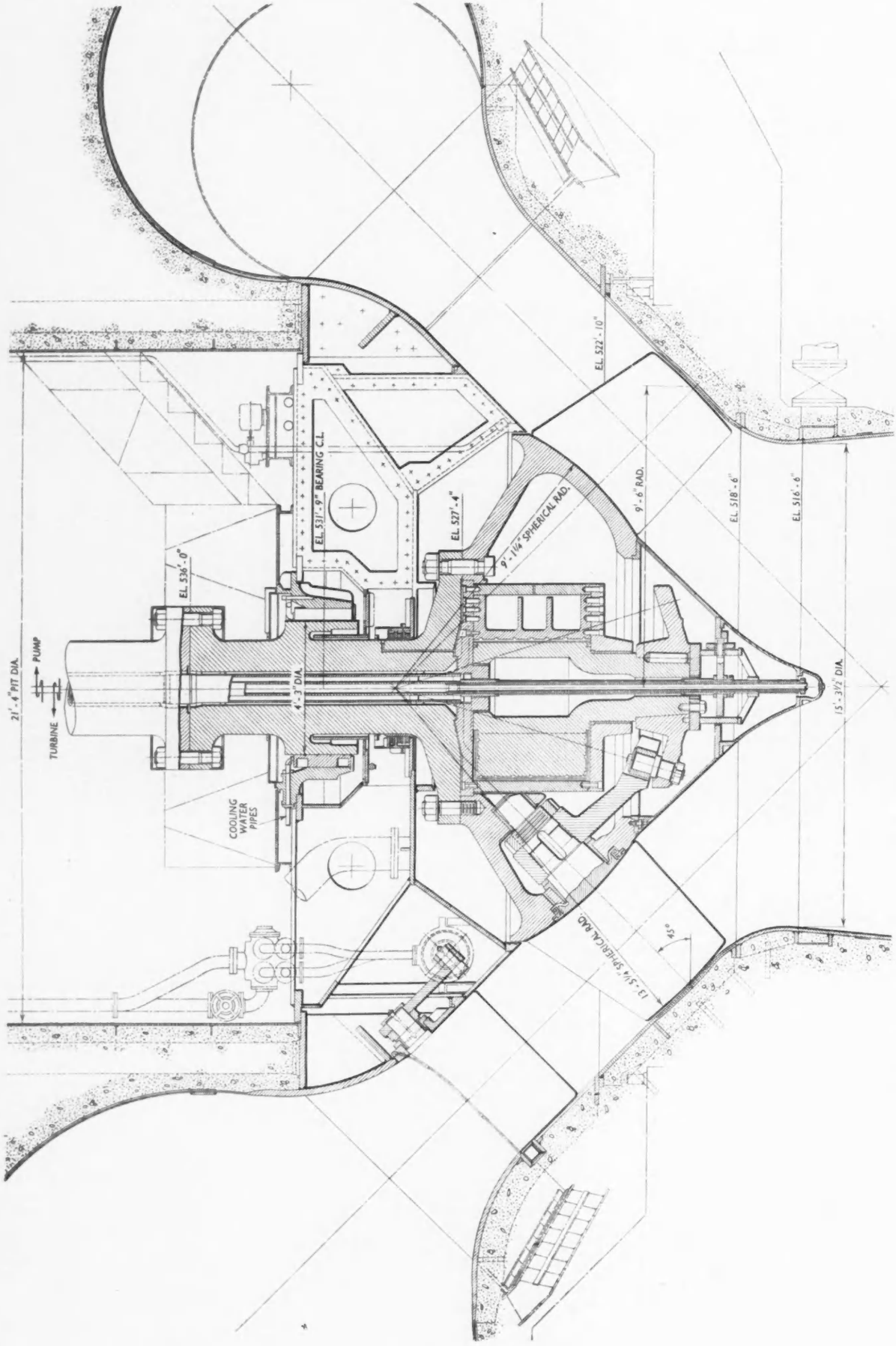


Fig. 43—Sectional drawing of the reversible pump-turbine machine with adjustable blades installed at the Queenston pumping/generating station

this kind in North America—invite comparison.

As far as the Canadian works are concerned the organisation responsible for constructing and operating them is the Hydro-Electric Power Commission of Ontario. We should also add that in this case the simple outline description just given is complicated by the fact that there are two power stations in use at the main stage, the Sir Adam Beck-Niagara No. 2 station which was completed in the last few years, and the No. 1 station, which operates under similar hydraulic conditions but from a separate diversion system interconnected with the newer system serving No. 2 station. The No. 1 station was completed in 1921 ; it has an installed capacity of nearly 400MW, and was for many years the world's largest hydro-electric power station. Both stations, together with the pumped storage scheme,

Fig. 44—View from above the pump/turbine with the servo-motor removed, showing spider and blade levers

can be picked out in the heading illustration. There are four other Canadian power stations in the general area of the Falls, but these others are now of minor importance.

The No. 2 station has an installed capacity of 1200MW in sixteen 75MW sets. Twelve sets were needed to utilise the full flow available, the remaining four being added for use in peak load generation in conjunction with the pumped storage reservoir and pumping/generating station. The Sir Adam Beck-Niagara No. 2 station was described in THE ENGINEER at the time of its official opening, in our issue of October 1, 1954.

ECONOMIC APPRAISAL OF PUMPED STORAGE

The two Sir Adam Beck-Niagara power stations have a common forebay served by the two intake canals, which intersect just upstream from it. At this point another canal leads off to the pumping/generating station where there are six sets installed, each one rated at 31MW (generating) and comprising a generator/motor coupled with a Deriaz reversible pump/turbine operating with a range of heads of 60ft to 85ft. This station, like the St. Lawrence generating station, has an outdoor layout. The pumped storage reservoir is 15,000 acre-feet in capacity, and is formed by a clay-faced rock-fill embankment, into which the pumping/generating station is incorporated. The rock-fill and clay used in constructing this ring embankment came from excavating the canal of the No. 2 station. The pumped storage scheme is thus a straightforward installation for meeting daily or short-term peaks. Its special interest lies in the use of the Deriaz pump/turbine and in a rather unusual design appraisal of its economic advantages.

When design of the pumped storage scheme was being considered by Ontario Hydro, the basic situation was the same as that governing pumped storage in this country, namely, that the alternative installation was a thermal power station, by comparison with which the pumped storage scheme needed to show some economic benefit. The St. Lawrence power station—described in Part X—was considered essentially a base load installation, and " over development " of other small hydro-electric sites remaining unexploited, to suit them for peak loads, would still have given insufficient peak capacity. The actual study of the comparative costs of the two peak-load alternatives was, however, quite unusual because of the special conditions imposed by the Niagara treaty. This aspect of the scheme was described by Mr. M. Ward in a paper (Ref. No. 42 A1/3) presented at the sectional meeting of the World Power Conference held in Montreal a year ago. Mr. Ward's statement of the problem is reproduced from his paper herewith.

" Since the minimum flow over the Falls is fixed by the treaty, any change in river flow is reflected in the diversions for power. Thus, the permissible diversions are governed by three main factors. First, under the terms of the treaty the Canadian diversion in the tourist season changes by 25,000 cusecs from daytime to night-time and vice-versa, and is contrary to load requirements. Secondly, wind effects on Lake Erie cause rapid random variation in river flow. Without pumped storage and with a twelve unit Sir Adam Beck No. 2 plant assumed in operation total power generation could vary from, say, 930MW at 11·00 hours to 1650MW at 20·00 hours due to this effect. Thirdly, there is a long-term cyclic variation in river flow depending upon the amount of water impounded in the Great Lakes. The first and second factors are superimposed on the third and, from the standpoint of day-to-day operation, the main characteristic of the diversion is its hour-to-hour variation and particularly the sudden changes in the tourist season imposed by the treaty.

" The cost of maintaining adequate reserve capacity to guard against the variation in diversion would be large, and it was evident that provision of storage at Niagara would be desirable.

" In June, 1952, the decision to install twelve units in the Sir Adam Beck No. 2 plant was made, but it was recognised that in the early years of its operation there could be deficiencies of generation in the tourist season even though the installed system capacity was adequate to meet the higher winter demands. This effect would decrease as system demand increased and disappear when the difference between the summer and winter daytime outputs of the Niagara plants became equal to the seasonal variation in load between summer and winter. However, regardless of the load level, the summer-time daytime-night-time variation in generation would result in lower load factor operation of thermal plants, with consequent decrease in efficiency. This situation would be relieved if water storage were provided.

" Since the land adjacent to the forebay at the Sir Adam Beck plants is at a higher elevation, a large amount of excavation would be required to extend the forebay. Therefore, some form of pumped storage would be required. If a pumped storage project were developed at the Sir Adam Beck plants, but no additional capacity provided at these plants, it would be possible in the tourist season to transfer water into storage at night-time and use it in the daytime when the diversion is less than the full capability of the installed capacity at these plants. This would overcome the summer-time deficiency and obviate the need for additional capacity to supply this deficiency.

" It would also permit the Sir Adam Beck plants to operate at full capacity at time of system peak demand in all months without the complication of building up the forebay elevation prior to peak to permit full gate operation at peak. Forebay build-up would

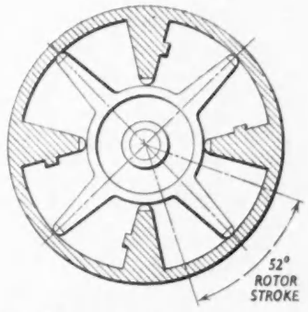


Fig. 45—Sectional diagram of servo-motor

result in loss of capacity prior to peak demand and, without a structure to control the flow of the Niagara River completely, would also result in an irrecoverable loss of water over the Falls.

" It might also prove economical to use reversible pump turbines for peaking capacity and install additional capacity at the Sir Adam Beck plants to operate in conjunction with the pumped storage scheme. In this manner, the overall system peak capability might be economically increased. This additional peak capacity would have to be more economic than any other alternative of adding peak capacity to the system.

" In the long term, when the load has increased to the point that the night-time summer load can utilise the full diversion, the need for transferring energy from night-time to daytime will disappear. At this and greater loads, the pumped storage would be useful for short-time peaking duty. However, the storage required to satisfy the initial requirement of transferring energy from night-time to daytime would be greater than that required to provide only peaking capacity and the desirability and feasibility of adding still more peaking capacity to utilise the water storage would then be considered."

The paper continued with notes on how the additional plant capacity at the main station and the capacity of the pumping sets were determined, and of how the size of the reservoir was assessed. In fact, consideration of " still more capacity " to meet peak loads once the night to day difference had been surmounted, as mentioned in the last sentence of the abstract, proved to be uneconomic, and whereas 15,000 acre-feet of storage gave an economical solution, for the reasons outlined, the addition of a further 5000 acre-feet of storage would have proved uneconomic, the extra power generated over a ten-year period by this increase proving more expensive than the purchase of a similar amount of power from neighbouring systems.

The scheme, as built, comprises four

additional 75MW sets at the main station, plus the six pumping/generating sets, giving a grand total of 486MW (generating) and corresponding increases of peak capacity of 770MW for the October peaks, and 526MW for the December peaks, these last two figures corresponding to river flows obtaining for 85 per cent of the time. The capital cost of the scheme was practically identical (75,500,000 dollars as against 78,500,000) with the estimate for a thermal station giving the same peak capacity (i.e. 526MW net), but the annual charges show a saving of about 2,500,000 dollars for the pumped storage scheme, the totals being respectively about 7,5.0,000 dollars and 5,000,000 dollars in the two cases.

This saving excludes benefits inherent in the pump-storage scheme due to operational factors which will vary from year to year, according to river flows and system loads ; they were summarised by Mr. Ward under four categories, viz. minimising wastage of off-peak energy, or its sale at low rates ; allowing more economical loading of thermal stations ; providing low-cost stand-by power; and allowing storage of energy over week-ends and holidays. The plant normally operates, however, on a daily cycle. It was completed last year.

The Deriaz Pump/Turbine

Many of our readers will be familiar with the Deriaz machine, which has already been referred to in these columns (see THE ENGINEER, July 6, 1956, page 13, and January 17, 1958, page 106). Essentially it combines the mixed-flow principle of the Francis turbine with the adjustable blades characteristic hitherto of only Kaplan turbines. A flat efficiency curve, as for the Kaplan turbine, is thus obtained, and a reasonable pumping head—limited to 30ft for an axial flow or " Kaplan " pump—can be obtained when the machine is operated in reverse.

In addition the general design incorporates a number of other advantages which, very briefly, can be stated to give simplicity and flexibility in operation. These aspects of the new pump turbine were commented upon in our earlier articles,† and will not be enlarged upon again here, but in view of the originality of the machine, and of the current interest in reversible machines for pumped storage, we conclude with a description of the mechanical features of the Deriaz pump/turbine as installed at the Niagara scheme.

The development work leading up to this first actual application of a highly original design, was carried out by the English Electric Company, at its hydraulic department at Rugby, and in fact the machine takes its name from the firm's chief hydraulic designer. Manufacture of the turbine blades was carried out at the company's Netherton works, but the rest of the manufacture was in the hands of English Electric, Canada–John Inglis Company.

The accompanying drawing (Fig. 43) shows a section through the machine. The alternator/motor is of conventional " umbrella " design, and the thrust bearing is carried on a bracket immediately below it. The shaft is held again lower down by a guide bearing, which is shown in the drawing. The pump/turbine has eight blades, each of which can be feathered about an axis at 45 deg. to the vertical. The runner hub and the " skirt " or envelope surrounding the runner are both spherical ; thus tip clearances are unaltered when the blades are feathered. In the fully-closed position the blades form a closed cone.

† See also " Reversible Pump Turbines for Sir Adam Beck-Niagara Pumping-Generating Station," by P. Deriaz and J. G. Warnock, A.S.M.E. Paper No. 58–A108, November/December, 1958, and " Economic Advantages of Variable Pitch Runners for Water Turbine Pumps," Paper No. 130A,5, by the same authors. World Power Conference, Montreal, September, 1958.

TABLE XII—*Data for Deriaz Pump Turbine*

For turbine operation :	
Range of net heads, ft	40-90
Corresponding range of power output, b.h.p.	24,000-45,000
Speed, r.p.m.	92·3
For pump operation :	
Range of net heads, ft	40-90
Corresponding range of discharges, cusecs	4,050-5,040
Speed, r.p.m.	92·3
Runner diameter, ft	21
Effective runner diameter :	
Blades fully open, ft	21
Blades closed, ft	19
Number of runner blades	8
Weight of rotating parts, lb	400,000
Maximum hydraulic thrust on rotor, lb	850,000
Static thrust with pressure-relief vent closed, lb	1,150,000
Maximum total thrust, lb	2,400,000
Blade tip clearances (measured normal to envelope) :	
Minimum permissible running clearance, in	0·10 ± 10 per cent
Blade clearances for stationary machine, in	0·020 to 0·040
Servo-motor data :	
Inside diameter of servo-motor cylinder	5ft 11in
Height of cylinder	3ft 9½in
Operating pressure, lb per square inch	350
Energy of servo-motor, ft lb	2,500,000
Speed ring loading :	
Number of stay vanes	6
Vertical load on each stay vane, tons	424
Direct compression in each stay vane, tons	600
Average stress in stay vane :	
Calculated, lb per square inch	5,000
Measured (on model), lb per square inch	4,500
Maximum stress in stay vane (at leading edge), lb per square inch	10,000
Maximum stress in speed ring, lb per square inch	5,500
	Per cent
Percentage of rated power needed to operate fully-feathered turbine and generator at 92·3 r.p.m.	5
Nominal efficiency at mean head :	
For turbine :	
40–100 per cent load	92
130 per cent load	90
For pump	90

A servo-motor concentric with the main shaft controls the blades through a spider and blade levers. The essential feature of this mechanism is the intersection on the centre line of the main shaft of the axes of rotation of the blade trunnions and of the blade levers on the spider. We illustrate (Fig. 44) the sliding blocks on the spider engaged by the forked ends of the blade levers.

A sectional diagram of the servo-motor (Fig. 45) is also given from which it will be seen that it has four fixed vanes and a rotor also with four vanes. Since the forces involved in adjusting the blades are large, the servo-motor is correspondingly powerful ; its principal data are listed in the table. The servo-motor is sealed by bronze staunching bars and rings, loaded both by springs and by the hydraulic pressure ; there are overlapping seals at the corners. Under normal operation, the worst conditions encountered require that the servo-motor should produce about half of the energy of which it is capable.

The governor mechanism is outside the turbine the same as for a Kaplan machine. To operate the governor restoring mechanism, rotation of the servo-motor rotor relative to the turbine hub is converted into axial displacement of a tube which passes up the centre of the shaft. This conversion is achieved by a cam mechanism in the bottom of the hub. The mechanism operating the governor restoring tube can be seen in the bottom of the hub in the sectional assembly drawing. It consists of an arm attached to the restoring tube which is held in guides attached to the runner hub in order to prevent rotation of the tube relative to the hub. There is also on the arm a roller moving in a helical slot cut in a cylinder attached to the rotating servo-motor. When the servo-motor operates the roller is forced by the helical slot to move axially up and down.

There are six stay vanes in the speed ring, each with an adjustable flap which may be deflected by a servo-motor to alter the angle of approach of the water in turbine operation at heads below 60ft. In addition, for operation as a pump the flaps are preloaded against the stay vanes when " in line," so as to avoid backlash and vibration.

The entire loading from the weight of the generator rotor and turbine, hydraulic thrust, and part of the concrete superstructure is transmitted through the six stay vanes. Their design was thus evolved to eliminate bending as far as possible, and the whole speed ring assembly was tested using a structural model.

The pump/turbine is of welded construction, except for the runner, shaft and bearing. The blades are precision castings in mild steel, hand-ground and finished to give closely-fitting sealing surfaces, and with stainless steel inserts at their tips. The envelope is lined with stainless steel.

The fact that a completely closed cone can be formed by the blades is advantageous in that the machine can be operated without conventional gate apparatus and without depressing the tailwater by compressed air if operation as a synchronous condenser is called for. Very little torque is needed to bring the machine up to speed with the blades completely closed. Changing over from one mode to the other is also straightforward, involving closing the blades, stopping, and re-starting in the opposite direction of rotation.

One other device has been incorporated to make the operation of the machine without guide vanes practicable. When it is shut down, the runner is displaced axially downwards, to reduce the tip clearances of the blades, and hence reduce leakage to an acceptable degree. This is done by increasing the downthrust on the runner by closing the pressure relief pipe. This pipe normally carries the water leaking past the runner seals from the top of the runner to the draught tube. When it is closed, the full upstream head is operative over the top of the runner hub, thus increasing the thrust. This increased thrust is then sufficient to deflect the runner assembly downwards to give precisely the required small blade tip clearance. This is done by virtue of the jacks below the thrust bearing. These jacks are standard equipment for an alternator, but in this case they have been modified so that, in addition to their normal function, each one incorporates a preloaded composite tension bar, which has a load/deflection curve giving the " deflection rate " needed for sealing. That is to say, the composite bar has a very rigid element, then an element allowing deflection within the precise range sought, and finally another very rigid element, the latter preventing the blade tips actually coming into contact with the envelope.

Each jack has a load cell and strain gauge installation for calibration. The jack can be removed easily as a maintenance procedure, and it allows a considerable range of adjustment around the computed maxima and minima for deflections as established by calculation. Pressure lubrication of the thrust bearing at speeds below 46 r.p.m. ensures that there is no breakdown of the oil film. The runaway speed is 208 r.p.m., as against the normal 92·3 r.p.m.

One June 1, 1959, the six Niagara sets had generated 239,859MW-hours and had pumped 381,638MW-hours. It is expected that by the end of this year the machines will have absorbed over 400,000MW-hours on pumping duty and a proportional increase in generating duty also. In these figures the ratio of one to the other is not a true measure of the overall efficiency since it involves modes of operation which do not show the machines in their best light.

Recent Production Developments in the Soviet Union

No. I

The Sir Alfred Herbert paper for 1959 was presented to the Institution of Production Engineers on Thursday, December 10, by Dr. D. F. Galloway, director of the Production Engineering Research Association of Great Britain. In his paper, Dr. Galloway gave some impressions obtained during a five-week tour of the Soviet Union, Poland and Czechoslovakia by a delegation from P.E.R.A. The observations were mainly concerned with production engineering research and development, general industrial development, and the engineering and scientific information services in the countries visited. Dr. Galloway's paper is of particular interest to all engineers concerned with research and development, and abstracts from it are given below.

Russian Factories

MOST of the Russian factories visited were generally similar in appearance to British factories, except that in Russia natural and artificial lighting of working areas is usually inferior, little use is made of colour for decorative purposes, and on average there is more overcrowding. Standards of cleanliness were generally good, and ageing women were often seen sweeping up dust and swarf with crude brooms.

Despite the intensity of the present drive to introduce automation in Russia, only limited mechanical handling facilities were available in some of the factories, although managements appeared to be conscious of the need to eliminate unnecessary handling and improve handling efficiency by introducing improved equipment.

The working tempo was certainly no higher than in the average British factory, and in some plants was somewhat lower, despite the fact that practically all production workers can earn substantial incentive bonuses.

Much of the production equipment in use was modern and well-maintained. Large numbers of machines have been purchased from Czechoslovakia, Germany and elsewhere, but very few British machine tools were seen. It is clear, however, that the Russian engineering industry is depending increasingly on machine tools produced in the Soviet Union for the present ambitious programme of expansion. Only a small number of new machine tools manufactured in countries outside the Socialist bloc were seen.

Production techniques were generally efficient, and high rates of metal removal were often being achieved. The best Russian factories have established very close links with research establishments such as ENIMS, VNII, TSNITMASH and ENIKMASH, and enthusiastically apply the results of investigations carried out by these and other central research stations. The results of research conducted in the production engineering research laboratories of individual factories are also intensively applied in production.

Of the various Russian factories visited, three of particular interest were the First State Ball-Bearing Plant, the Krasni Proletarii Lathe Factory in Moscow, and the Sverdlov Machine Tool Plant in Leningrad.

The First State Ball-Bearing Plant in Moscow produces about 70,000,000 bearings annually, ranging in size from ¼in to 5ft outside diameter and varying in weight from approximately 1 oz to several tons. About 12,000 people are employed on the quantity production of bearings in six departments which include a separate automatic factory. This automatic factory was built in 1952 for the production of ball bearings approximately 4in and 5in outside diameter.

Considerable organisational skill and great ingenuity have combined to make this automatic factory an industrial development of great significance and interest. The factory is producing 2,000,000 bearings a year with a labour force of twelve production workers and eighteen maintenance engineers. The automatic line comprises 150 machine tools, several heat treatment furnaces, special assembly presses, inspection equipment and a unit for greasing, wrapping and packing the bearings.

One of the most progressive machine tool factories in Russia is the Krasnii Proletarii plant in Moscow, which celebrated its 100th anniversary in 1957. About 5000 people are employed at the factory, over 30 per cent of whom are women, and the output consists mainly of three sizes of standard lathe which are designed to facilitate their inclusion in automatic lines by the provision of fixing points for transfer mechanisms, &c. About 900 to 1000 standard lathes are produced monthly, and thirty to forty special-purpose machines are also built each month.

The Krasnii Proletarii Factory is one of about ten suppliers of lathes to Russian industry, and it is claimed that these lathes are the cheapest in the world. Flow line production has been adopted wherever possible, and thus considerable use is made of automatic machines, transfer lines, conveyorised assembly, and modern work handling equipment. Two fully automatic transfer lines have been installed in recent years, and a third fully automatic line for the production of stepped shafts designed by ENIMS is also being installed.

The mass production of machine tools at this factory has been made possible by the rationalisation of the Russian machine tool industry, high technical skill in the application of mass production techniques in the manufacture of precision components, and by the high demand for machine tools by the Soviet bloc.

The Sverdlov Machine Tool Works, Leningrad, is also one of the oldest factories in Russia, and has been producing machine tools since about 1917. Since 1939 the plant has specialised in the production of boring and milling machines, copy milling machines, and semi-automatic milling machines and has recently commenced the manufacture of large jig borers. A wide range of special purpose machines for the manufacture of diesel engines, turbines, locomotives and ships is also produced.

A considerable amount of research into many aspects of machine tool design and construction has been carried out for several years in the factory's well-equipped research laboratory. This work has embraced investigations of machine tool vibration, co-ordinate setting and continuous path programme control, electro-mechanical drives, friction (especially stick-slip), elimination of backlash in lead screws, &c.

It was claimed that considerable progress had been made in overcoming vibration in machine tools by the practical application of theories of vibration developed by the factory's research engineers. The dynamic and static rigidity of machine tool elements such as columns, are investigated by means of 1 : 5 scale models, and the model tests results have been satisfactorily correlated with the results of tests on full-scale machines. Practical application of the experimental results has led to substantial improvements in design. For instance, the overall size of one standard type of machine tool has been increased by one-quarter, and the power of the motor has been increased by one-third without increasing the weight of the machine, as metal has been much more effectively distributed.

Several different types of numerically controlled boring machines have been developed, the control systems being based on the use of punched cards and dials.

Czechoslovak Factories

Our observations in Czechoslovak factories revealed a very rapid growth in industry in general and in the engineering industry in particular. In the ten years between 1948 and 1958, engineering production increased five times and general industrial production three times. Czechoslovakia's growing economy and increasing standard of living is based on an increasing foreign trade. The vast export markets in the Soviet Union, China, and elsewhere have made possible rationalisation and a scale of production which could not be supported by internal requirements.

Czechoslovakia's industrial expansion owes a great deal to the progressive machine tool industry backed by an excellent machine tool and metal cutting research centre. This virile industry has expanded very rapidly in the past ten years, and has also greatly improved the quality of its products.

Two of the most outstanding Czechoslovakian machine tool factories visited by the delegation were the TOS Kurim machine factory at Brno and the TOS Kuvosit factory at Sezimovo Usti. The TOS Kurim, one of the largest milling machine factories in the world, manufactures about 3000 machine tools a year, and has about 5000 employees, of whom about 300 are designers and draughtsmen. In general, the factory produces standard vertical, horizontal and plano-type milling machines. Some machines are programme controlled, and special purpose machines and transfer-lines are also manufactured. About 50 per cent of the total production of the factory is exported to seventy-four different countries.

The TOS Kuvosit factory employs 2000 people, and manufactures single spindle automatics, copying lathes and radial drilling machines. Following the rationalisation of the Czechoslovakian machine tool industry, this factory is now concentrating mainly on radial drilling machines.

Since the war, the output of presses and other metal forming equipment has been greatly expanded in Czechoslovakia as industrial interest has quickened concerning the possibilities of conserving materials, reducing manpower requirements, and increasing

production efficiency by fully exploiting the potentialities of metal forming. The total output of forming equipment of all types has been raised five times since 1948, and by 1965 is expected to increase about three-and-a-half times. The range of equipment produced has also widened considerably, and special attention has been given to the design and construction of mechanised and completely automatic special-purpose press and production lines, and unit head presses.

The Czechoslovak pressworking industry was reorganised in 1958, and factories which previously produced forming machines were merged into one economic unit at the Smeral Works, Brno. This factory, together with the Research Institute for Forming Machines and Forming Technology, Brno, is responsible for all technical development in the press working industry. The Smeral Works also controls other plants manufacturing forming machines as a secondary activity.

One of the developments which has taken place in the manufacture of metal forming equipment in Czechoslovakia in recent years is the construction of a wide range of unit head crank presses with welded frames which can be assembled into 320 different units. These presses have been successfully employed for cold extrusion and difficult upsetting operations. Unit construction has also been adopted for eccentric presses, which have been specially braced to permit the use of press tools tipped with cemented carbide. The range of heavy duty vertical forge presses has been extended to include presses with capacities between 630 and 4000 tons. By increasing the rigidity of the frames of smaller die forging presses of this type, higher accuracy has been achieved in the production of forgings. These presses have also been provided with special attachments for simple and accurate setting.

Production Engineering Research in Russia

Much of the great technical vitality of the best Russian factories is derived from intensive research being carried out at a number of large research laboratories with excellent equipment and scientific staffs of the highest calibre. About 10,000 are employed on production research and development in these central research stations and, in addition, the larger factories have their own production research and development departments doing work which is impressive in its range and quality. Although it is commonly assumed that Russian research facilities are wholly financed directly by the State, research projects sponsored by particular factories account for a large proportion of the total activity and income of some research stations. For example, approximately half the income of the Central Scientific Research Institute of Technology and Machine Building (TSNITMASH) is derived from sponsored research carried out for particular factories.

Two of the central research stations visited in Russia were ENIMS (Experimental Scientific Research Institute for Machine Tools) and TSNITMASH (Central Scientific Research Institute of Technology and Machine Building).

ENIMS—Experimental Scientific Research Institute for Machine Tools

ENIMS is concerned with fundamental and applied research relating to machine tools, with the design, testing and development of machine tool prototypes and with the general development of automation including complete automatic factories. The Institute has a total staff of about 1800, of which approximately half are engaged on research and half on development. About 50 per cent of the research and design staff are women, many of whom are well qualified and experienced engineers. The Research Section of ENIMS is conducting extensive research into machine tool design and performance, automation, metal cutting, machine tool mechanisms, hydraulics, electronics, electrical equipment, &c.

ENIMS' functions also include the determination of the most suitable ranges of standard machine tools needed by all branches of Soviet industry, assessing the numbers of machines required by the engineering industry, and drawing up plans for the erection of specialised machine tool factories. In discharging these functions, the Institute has made a special study of machine tool developments in other countries.

ENIMS has played an important part in extending the range of machine tools now produced in Russia. In 1935, only 200 types of machine were manufactured, but by 1960 the number of different types of machine tools being manufactured is expected to exceed 1200.

Since the war, ENIMS has designed 128 types of machine tool which are now in production, and has also developed nearly all the standard types of hydraulic equipment and hydraulic drives, and more than 70 per cent of the specialised electrical apparatus incorporated in Russian machine tools. Methods of calculating life and performance of standard machine components have been devised, and tables based on these calculations enable designers to determine very quickly the dimensions of components for a special duty. The Institute has also been carrying out investigations over a number of years to determine the most suitable design for a cheap and reliable infinitely variable mechanical drive, a stepless hydraulic drive, and various electrical systems for stepless speed regulations.

ENIMS has developed, in conjunction with the Joint Designs Bureau, an electro-impulse machining technique which, compared with electro-spark machining, has increased metal removal rates eight- to ten-fold, and increased electrode life ten to 100 times. As in electro-spark machining, the workpiece is immersed in a dielectric fluid, but in electro-impulse machining, continuous arc discharges occur at a fixed frequency. The principal difference between electro-impulse machining and electro-spark machining is the use of the arc discharge instead of a spark, pulsed impulse, instead of direct current impulses, and the substitution of a special generator for condensers. Operations for which this machine has been employed include the machining of forging dies, the production of complex profiles in sheet materials, carbide dies, and irregularly shaped external surfaces, and extracting broken tools, &c. It is estimated that the machine will pay for itself in three to four months of normal use.

ENIMS has done considerable work on the development of standard test charts for many types of machine tool, and is now wholly responsible for the introduction of new test charts and the revision of existing charts in the U.S.S.R. German test charts were formerly extensively used in the Soviet Union, but they have now been substantially modified, especially during the last few years, and further revisions are to be made in the near future. Soviet engineers consider that existing test charts do not adequately take into account the size of the machine tool, and the test charts developed at ENIMS relate specifically to particular sizes of machine. Test charts have been introduced for three grades of machine tool, namely, standard, precision and extra-precision. All Russian factories producing machine tools are under a legal obligation to test all completed machine tools in accordance with the Standard Test Charts, and may be prosecuted for failing to undertake tests, or for producing machines which do not conform to the requirements of the Charts. Inspectors controlled by the Standards Committee responsible for the administration of the laws on standardisation regularly visit factories to ensure that standards are being observed. Many large users of machine tools also test machines in accordance with ENIMS test charts.

ENIMS' scientists and engineers are devoting considerable attention to the problems of modernising about 20 per cent of all machine tools in Russian factories. It is hoped that as a result of this work, the rate of production of the modified machines will be increased, on average, by 30 per cent.

It is claimed that a system of planned maintenance which has been developed by ENIMS has yielded an annual saving of 280 million roubles in wages, and reduced idle machine time in Russian industry by 45,000,000 hours. These savings are equivalent to an increase of 9500 in the number of machine tools actually available for use in Soviet factories.

TSNITMASH—Central Scientific Research Institute of Technology and Machine Building

TSNITMASH, the Central Scientific Institute of Technology and Machine Building, was founded in 1928 during the period of the first five-year plan of economic development. It occupies a site of about 7 acres approximately 5 miles from the centre of Moscow and comprises the Research Institute with a floor area of about 250,000 square feet and the Perovsky Experimental Production Plant. The total staff is about 4400, of which one-third are engaged on production research, one-third are employed at the Experimental Plant and the remainder on research and development concerning engineering materials. At the Experimental Plant the main activities are the development, building and testing of prototype machines and of other new equipment, and the testing of new manufacturing techniques.

TSNITMASH's researches include the improvement of existing production processes, development of new production processes, research into metals-working equipment, such as rolling mills, and the development of new materials for heavy industry. Research is carried out into many different types of problem which arise during manufacture, and thus a series of investigations into various aspects of the manufacture of a particular product may proceed in parallel.

The director is Dr. Unksov, an international authority on metal forming processes, and the deputy director is Dr. N. N. Zorev, who is well known in Western countries for his work and publications on metal cutting. Each department in the Institute is limited in size to 150 or 200 staff, as this is considered to be the maximum number for effective control and administration.

The Institute receives approximately half its income from the State and half from industry in payment for sponsored researches. About two years ago, the Soviet Govern-

ment suggested to the Institute that it should be supported entirely by the State, but this proposal was rejected, as it was considered that it would weaken the Institute's close links with industry and thus adversely affect the quality of its research, as well as impede industrial application of research results. Researches of general industrial interest are usually financed by the State. Although some of the largest factories have their own research laboratories, close links are generally maintained with TSNITMASH, where special knowledge and facilities are available over a very wide field of technology. The Institute directly assists about 400 factories in all, although research reports and other publications are issued to many more plants.

TSNITMASH is making important contributions to the improvement of production techniques and equipment. During the course of investigations into milling operations on high strength steels, special milling cutters have been developed with high rakes, relief angles, and helix angles, and rates of metal removal have been raised five times without reducing tool life. An impressive demonstration of the performance of this type of cutter was given during a milling operation on a 13 per cent chromium nickel steel, the workpiece being traversed at the rate of 15in per minute. However, the surface finish of the machined surface was impaired to some extent by cyclic ridges.

In tests which were in progress on ceramic tools, a 0·5 per cent carbon steel shaft was being cut at a speed of 2600ft per minute, 0·040in depth of cut, and feed of 0·008in per revolution ; a carbide tool failed immediately when an attempt was made to machine the shaft under the same conditions. Ceramic tools are apparently rarely used in production operations, and are generally restricted to the machining of large components of relatively simple shape.

As a result of investigations undertaken by TSNITMASH, new processes have been developed for rolling gears, complex profiles, half-shafts for cars, axles for railway rolling stock, tubes of various shapes, &c. Research has also been carried out which has resulted in the design and construction of new hydraulic presses, including a 70,000-ton press completed about three years ago for the production of aircraft components. The columns of this press were nearly 100ft high. TSNITMASH designed and constructed the press because Soviet industry had no previous experience of presses of this size.

Equipment has also been developed at the Institute for finish rolling turbine blades to close limits of accuracy. It is claimed that blades can be produced within 0·004in, compared with a tolerance of about $\frac{1}{16}$in for conventional forging. Apart from final cleaning up operations, the blades are produced entirely by rolling.

(*To be continued*)

Characteristics and Protection of Semiconductor Rectifiers

In a paper presented by D. B. Corbyn and N. L. Potter,* for discussion at a meeting of the Utilisation Section of the Institution of Electrical Engineers in London on December 9, the authors dealt with the characteristics and protection of semiconductor rectifiers. The paper examined the protection requirements under normal, overload and fault conditions, and showed that high-rupturing-capacity fuses provided a basis for protection. The practical application of these fuses was described, and abstracts from this part of the paper are given here.*

THE advent of germanium and silicon semiconductor rectifiers has completely altered rectifier protection requirements. These rectifiers are simple and small, and give a uniformly high efficiency over a wide range. However, they are susceptible to damage by over-currents, owing to their small thermal mass, and to damage by over-voltages, owing to breakdown phenomena. Their advantages can be fully realised only if proper protection can be applied. This paper is devoted to a study of the protection requirements and the manner in which they depend on the basic properties of the rectifier itself. The protection requirements are :

(*a*) Establish voltage and current ratings giving an acceptable life for the device.

(*b*) Control voltage and current surges generated by the equipment.

(*c*) Guard against occasional cell failures ; devise means for detecting these and disconnecting faulty cells before cumulative damage occurs.

(*d*) Co-ordinate the protective measures to prevent unnecessary interruption of output.

To protect properly it is essential to know the margin between the safe working and failure limits for both current and voltage under both steady-state and transient conditions. It is also necessary to have some knowledge of the reasons for failure if the protection is to be better than a mere trial-and-error system. The rectifier properties are studied in the paper, and suitable protection proposals are made on the basis of this study.

* The English Electric Company, Ltd.

Protection in Practice

Fuses give satisfactory protection for semiconductor rectifier cells. Indicating striker-pin fuses are connected across the main fuse groups. When the main fuse clears, current is diverted through the small fuse, melts its element and a spring ejects a small striker pin. This pin operates a microswitch which can either give an alarm or trip the equipment. This system of warning is cheap.

It is not necessary to change fuses while the equipment is working, but rectifiers have been made with sections withdrawable under load, so that servicing can be carried out without interruption of output.

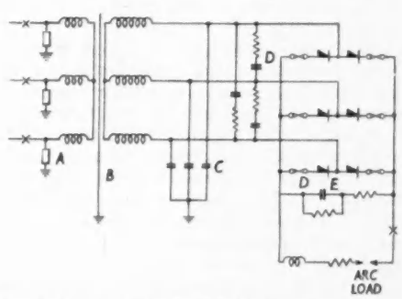
For small equipments the blowing of a fuse is made to trip the equipment. It is obvious that with only one, two or three parallel paths per rectifier arm, severe overloading of the remaining rectifier cells would occur if the equipment was not switched off. In large installations with many rectifier cells in parallel a warning of rectifier cell failure is adequate and allows the operator to replace the faulty cells when convenient. In borderline cases, methods are used by which the failure of one or more rectifier cells modifies the protective relay system and compels the operator to reduce load.

General-Purpose Power Supplies.—D.C. power supplies for factories, steelworks, docks, &c., usually have variable loads with frequent overloads. Maintenance of supply is often vital, even though system short-circuits may occur.

In many systems the rectifier feeds the d.c. busbars through an isolator without any main d.c. circuit-breaker. The feeders would be supplied either through small feeder circuit-breakers or h.r.c. fuses. Where the percentage of total power on any one feeder is not too high, the risk of blown rectifier fuses is negligible, and the only case where this is likely to happen is with a direct short-circuit on the rectifier output. The equipment is constructed to render this unlikely. A small but important point is to see that busbars cannot be bridged by vermin.

It is usual to set the a.c. circuit-breaker instantaneous trip at three-and-a-half to four times full load current, and use an i.d.m.t. relay to prevent long-term overloads. With these trip settings, measures may be necessary to prevent undesired trips by magnetising inrush currents.

D.C. circuit-breakers are sometimes essential, and the risk of arc chopping with production of voltage surges has to be faced. To overcome this, a capacitor is connected across the output of the rectifier with resistance in series (Fig. 1). This is chosen to



A—Surge diverters for lightning protection.
B—Earth screen. } Alternative protection against switching
C—Low-inductance capacitors. } surges due to capacitive coupling between transformer windings.
D—Capacitors for hole-storage and transformer-switching-surge protection.
E—*RC* circuit to absorb magnetic energy.

Fig. 1—Methods of surge-voltage protection

give any degree of voltage rise upon chopping the load current, and the resistance eliminates any voltage build-up due to resonances. For medium-voltage power supplies an electrolytic capacitor is satisfactory.

Some motors have regenerative braking, and when there is no other load on the system, a loading resistor switched in by over-voltage relays prevents dangerous voltage rises.

For operation of semiconductor rectifiers in parallel with mercury-arc rectifiers, the semiconductor fuses may blow if a backfire occurs in the valve. Circuit-breakers are not fast enough to overcome this when low-reactance transformers are used, but satisfactory discrimination can be obtained if the mercury-arc rectifier is fitted with anode fuses.

If a semiconductor rectifier is operated in parallel with a mechanical rectifier, the short-circuiter gives such fast protection that the only solution is either to increase the

reactance of the semiconductor equipment and then to rely on a circuit-breaker, or to use a short-circuiter on the semiconductor (Fig. 2).

Furnace and Welding Loads.—D.C. arc furnaces and welding equipment present special problems. Short-circuits are frequent, and the equipment must have a high reactance or be transductor (saturable reactor) con-

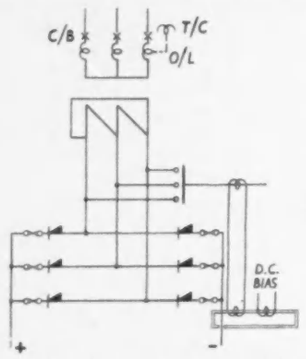


Fig. 2—Typical connection of a short-circuiter

trolled for operation down to short-circuit. Precautions are necessary in the design of transductor circuits to prevent severe surges of current or voltage.

Voltage rises due to chopping of the arc can be limited to a safe value by an *RC* circuit as shown in Fig. 1. [The basis of calculation is given in an appendix to the paper.]

Electrolytic Loads.—Loads are usually steady, and major short-circuits rare. D.C. circuit-breakers are often omitted, since rectifier cell fuses eliminate the possibility of a sustained short-circuit across the output busbars. Ordinary overloads can be cleared by the a.c. circuit-breakers. These installations are usually large, often supplied by e.h.v. overhead lines, and surge protection is necessary against damage due to lightning.

Industrial electroplating loads are similar in characteristic, but simpler, since only one equipment is involved and the lightning hazard does not usually exist. There is a risk of short-circuits on the output, but in practice these are of low current and hardly ever blow rectifier fuses.

Alternator Excitation.—These loads are free from voltage surges, and a short-circuit on the rectifier output is so rare that protection against it is not required. A shut-down is most undesirable, and rectifier sections are frequently made withdrawable under load for servicing.

With conventional alternators the rectifier can be connected direct to the field sliprings without any circuit-breaker. It then provides a discharge path for the stored magnetic energy in the field, with almost its inherent time-constant. When the stator of the alternator is subjected to a short-circuit, a heavy 50 c/s current surge occurs in the excitation windings. The rectifier must be designed to withstand this surge without harm. These rectifiers can be supplied by an alternator exciter mounted on an extension of the main alternator shaft.

In the brushless alternator the rectifiers are mounted on the shaft. The exciter alternator has rotating a.c. windings and a stationary field system. Centrifugal accelerations may be large—up to 1000 *g* or over. The electrical requirements including those of reliability are the same as for the conventional alternator.

Slip-Energy Recovery.—This is a system in which a bridge-connected rectifier replaces the rotor resistance of a slipring motor. The rectifier output supplies the armature of a d.c. motor mounted on the same shaft as the rotor. The rectifier-motor combination appears as a variable resistance when seen from the rotor. Speed control is obtained, and the power absorbed from the rotor is returned to the shaft via the rectifier and motor armature. The risk of voltage and current surges is small. Precautions are taken to disconnect the rectifier should the rotor electromotive force become too high through mishandling of the control gear.

Traction.—In some a.c. traction systems a high-voltage overhead line supplies transformers, rectifiers and control gear mounted on the locomotive or motor coaches. The semiconductor rectifier is steadily supplanting the mercury-arc rectifier for this duty. It is undesirable to use large numbers of fuses, and there is some preference for the cell connections in Fig. 3 (*b*) with the number of fuses kept to two per single-phase bridge. Cell failures can be detected, and replace-

Fig. 3—Series and parallel connections of rectifier cells

ments carried out, in the running sheds. The rectifiers and circuit-breakers must be designed to withstand the over-currents resulting from motor flashovers without the blowing of any fuse.

The overhead lines are liable to voltage surges due to lightning, and the rectifiers must be designed with both sufficient voltage margin and surge-voltage limiting devices.

Miscellaneous Loads.—It is impossible to catalogue all the varied loads in detail, each of which has its own protective requirement.

Battery-charging installations tend to employ rectifiers with short-circuit current limited by ballast reactance. Only backfire protection need be considered. There is a small risk of a battery being connected with incorrect polarity, so that fuses in rectifier arms give satisfactory overall protection. Engine-starting, switch-closing and surge-absorption rectifiers must be designed to withstand heavy overload currents.

Conclusions

The utilisation of the new semiconductor rectifiers requires protection against over-currents and over-voltages. For protection against internal faults, such as the backfire of a rectifier cell, or ultimate protection in case of a direct short-circuit on the equipment output, the h.r.c. current-limiting fuse offers a satisfactory solution. A protective system using fuses can be devised for most applications still allowing the use of normal reactance in the transformers. By the proper placing of fuses in the circuits, d.c. circuit-breakers can often be eliminated. The clearing time of all devices needs careful co-ordination.

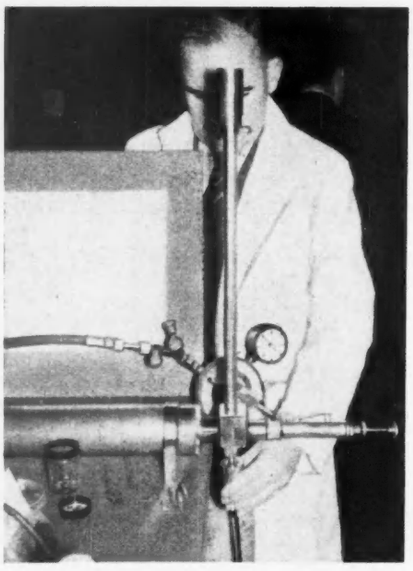
For over-voltage protection it is essential to protect against hole-storage voltages, transformer switching surges and in some cases chopping of the load current either by d.c. circuit-breakers or by special loads. For installations fed by overhead lines it is essential to protect against lightning by means of surge diverters, and to provide an adequate voltage margin in the rectifier cells. When all the protective systems are co-ordinated excellent continuity of power supply can be assured, and at the same time the protective system need not impose any serious limitation on the use of semiconductor rectifiers.

Science in Everyday Life

The Parliamentary and Scientific Committee held on Wednesday last week at the Royal Society its first Conversazione, at which there were displayed numerous exhibits based on the theme "Science in Everyday Life." One of the most ambitious demonstrations was a closed circuit colour television link, the transmitted picture being projected on a large screen for an audience in a darkened theatre. (In this system projection is inherent, blue, green and red light being mixed actually on the screen.)

Other exhibits included illustrations of techniques used in the study of the mechanics of the human body, the latter having included direct measurement of pressures within the body when engaged in lifting and sitting. Particularly interesting in view of the widely publicised attempts at present being made to identify and render recognisable electro-plate finishes likely to prove unsatisfactory in service was a technique for the non-destructive testing of plating. The method is intended to measure the thickness of a layer of nickel on another metal : a part-spherical stylus is placed on the plate and heated by a stable source, and the change in potential across the junction between the nickel and the base metal is observed. Given the thermal and electrical conductivities of both metals, a relationship between the temperature at the junction and the thickness of the plate can be derived, and the output calibrated directly in length units.

Another test for metal finishes, but a destructive one, has recently been evolved to measure the adhesion of paint to metal. The sample is a



Air gun for imposing shock loading on painted samples : the operator is closing the breech

small circle trepanned from the subject panel, with the paint removed by mechanical means from all except a small area in the centre. The sample is loaded on top of a thimble-like driver into a breech-loading air gun, and is fired against an anvil pierced with a central hole. The painted area faces the hole, and the retention or otherwise of the paint gives a go/no-go indication of the bond strength. The gun runs off a cylinder of compressed gas and is fired by allowing a spring-loaded plunger to strike against and unseat a normally-closed valve : the severity of the test can be varied by moving the starting point of the sample up the barrel.

More closely related to everyday life were a gas fire in which heat transfer surfaces were provided to take heat from the combustion gases to a secondary flow energised by convection, thus increasing the rate of dissemination of heat, and a proposal to incorporate in buildings a single vertical duct which would both supply primary air to gas heaters and carry away the products of combustion.

British Gas Industry's Progress

By V. S. SWAMINATHAN, M.A., M.Sc. (Lond.)

This review of progress in the gas industry in the United Kingdom deals with the activities of the British Gas Council in the light of reports by the British Productivity Team on the American gas industry in 1953, *and of the O.E.E.C. Gas Committee of September*, 1958.

EARLY in 1953 the Report of the British Productivity Team on the United States Gas Industry was published. Then natural gas accounted for 93 per cent of the thermal gas sales of the American industry, representing nearly a fifth of the energy derived from fossil fuels and water power, against 11 per cent in 1940 and less than 4 per cent two decades earlier. By way of contrast, over 80 per cent of the total gas available in Britain then was coal gas, and all of it had to be manufactured. The British team urged vigorous support for prospecting for natural gas in this country; intensification of research into the recovery of methane from coal mines; feasibility of importing liquid methane gas, and adoption, where practicable, of American techniques of long-distance transmission to extend gas grids, and so concentrate gas production in large modern installations.

The phenomenal growth of the domestic oil refining industry has resulted in a substantial increase in the availability of liquefied petroleum gas (LPG). The British team favoured the substitution of butane or propane mixtures for orthodox gas at existing small undertakings; provision for piped supplies of such gases to small communities lacking them; increased availability of bottled gas to scattered consumers, and the employment of such gases to meet peak loads. It was all for machines doing the pipe laying instead of men digging up the road to lay mains, especially for the development of long-distance transmission; and extending life of the distribution plant with cathodic protection. The long-term concern of the British industry pertains to the supply of suitable sources of gas, or gas-making materials.

The O.E.E.C. Gas Committee, set up in 1956, made four general recommendations last September: (1) gas should be fully exploited as a source of primary energy; (2) gas from coke ovens and the iron, steel and oil industries should be used to the best advantage; (3) research and improvement projects for the gasification of low-grade coal and petroleum products should be intensified to enable the industry to adapt itself to a reduction in the demand for coke and (4) long-distance gas transmission should be developed. So far as Britain is concerned prospects of gas consumption will depend on the success of current research into new raw materials and manufacturing processes; ability to keep prices competitive with other forms of energy, and development of longer-distance gas transmissions. It is no accident that the British Gas Council's activities follow the lines laid out by the Productivity Team, and the O.E.E.C. Gas Report.

Gas may be produced from both coal and oil. In the past the industry relied mainly on supplies of carbonising coal, but if gas is not to be over-priced in relation to petroleum products and electricity it will be necessary to make the best use of low-grade coal supplies arising from mechanisation of production, or employ oil as an alternative starting material. The Gas Council is, indeed, planning to employ both coal and oil as complementary fuels. Although the long-term goal is to use low-grade coal for gas manufacture, oil has also an important part to play in both the present and future; for it can confer three benefits: (1) gas supply can be expanded at lower cost; (2) processes gasifying oil are relatively flexible in the type of feedstock which can be employed, so that petroleum products in most abundant supply at any time can be used, thereby facilitating optimum refinery operation; and (3) coking coal will be saved to meet, for example, increasing demand by the domestic steel industry. From the gas produced in coke ovens and gas-making plants 325,000 tons of refined benzole were recovered in 1957, of which 200,000 tons were distributed as motor fuel in benzole mixtures. In short, coal and oil are increasingly becoming complementary rather than competitive both over the British economy as a whole, and for particular applications, notably gas-making and steel manufacture.

Unlike Italy, France, West Germany and Holland the United Kingdom is singularly short of petroleum and natural gas, and its hydro-electric resources are strictly limited. For various reasons its basic coal industry has remained static. This country pins its faith on developing nuclear power at the earliest possible opportunity to bridge the energy gap. In the meantime, town gas is increasingly being produced from various fractions of imported petroleum refined locally. Oil was first used in the gas industry for making water gas, which proved an asset for meeting the winter peak load.

Recent developments, first with the use of heavier oils, later, with light fractions, and employing high pressures and frequently catalysts, promise to make gas more cheaply than by carbonising coal by traditional methods. The British gas industry also uses tail gases from oil refineries, and it is importing liquid methane from Venezuela. A description of the gasworks installations employing the Onia-Gegi, Segas and Texaco processes, follows.

To convert petroleum products into a town gas suitable for distribution it is essential to alter the carbon/hydrogen ratio, which may range from something less than 5 : 1 to rather more than 7 : 1 in the material to be gasified, compared with 3 : 1 for natural gas or methane, and somewhat lower than 2·5 : 1 for normal United Kingdom town gas.

The Hall and Smet-Solvay processes were developed in the United States to convert heavy oil into a gas approximate in calorific value to natural gas. To this end, thermal cracking is adequate, but a residue of tar of high carbon/hydrogen ratio is left. The Pacific Coast type process, known in Britain as the Jones process, employs more intensive cracking conditions, and produces a gas fairly high in hydrogen, with carbon black as a residue. The catalytic gasification processes aim at minimising the output of tar and free carbon by converting at least a part of the latter into water gas by reaction with steam, and so producing a gas wholly, or nearly, interchangeable with town gas prepared by traditional methods. Reaction between carbon and steam, or hydrocarbons and steam, absorbs a good deal of heat. If the reacting hydrocarbon is of a relatively simple structure, like methane or ethane, and does not deposit carbon on the catalyst, the heat may be supplied, as in the U.S. Hercules Powder process, by plaeing the catalyst in heat-resisting tubes and surrounding them with a furnace, heated by a portion of the feedstock. But where, as with most petroleum feedstocks, the material to be gasified does deposit carbon it is convenient to employ cyclic operation, in which a make period alternates with a reheat period.

The C.C.R. system in the U.S.A., and the Onia-Gegi technique in Europe, use nickel catalysts. The European Segas process was developed to cope with heavier feedstocks, in which it was desired not so much to cause lighter hydrocarbons to react with steam as to ensure that as much carbon as possible should react instead of being deposited in the catalyst bed. In its original form the Onia-Gegi process was used for the production of hydrogen-rich gas from methane. With the latter free carbon is not deposited on the catalyst, and therefore, during the reheat phase of the cycle it became necessary to burn methane to heat the catalyst bed. This led to a plant designed for uni-directional flow.

The Segas process, on the other hand, being devised initially to employ heavy hydrocarbons, with which substantial carbon deposition could not be avoided, made use of a reverse flow system—the air being blown through the catalyst bed during the reheat phase in the opposite direction to that of the steam and hydrocarbon vapours. The reverse flow system permits heat to be recovered from the make gases by absorption on firebrick chequerwork to preheat the air admitted during the reheat period. Similarly, the blow gases stemming from the combustion of carbon during this period impart a portion of their heat to the firebrick chequerwork, and this is returned to the system during the make phase of the cycle by preheating the steam into which the oil is sprayed. The Segas blow and make cycles can be seen in the accompanying diagrams. Reverse flow is now used in Onia-Gegi plants built for the gasification of liquid hydrocarbons.

Cyclic catalytic processes have been found to operate efficiently with a wide variety of feedstocks, from gaseous hydrocarbons to residual fuel oils. Catalytic oil gasification plant was initially installed at conventional gasworks in Britain, the oil gas being used to supplement the production of coal gas and carburetted water gas. So far, some 40 units, with a total rated capacity of 120 million cubic feet a day, have been installed or ordered for this auxiliary function.

Two gasworks installations dependent solely upon petroleum products were commissioned late in 1958. At the Romford works of the North Thames Gas Board, four Onia-Gegi units, with a total rated output of 36,000,000 cubic feet a day, receiving refinery tail gases from the Shell Haven refinery and converting them into town gas, are operating. On the south side of the Thames, the gasworks at the Isle of Grain receive from the B.P. Kent refinery such a range of products as may from time to time be in long supply, and so help this installation to keep a balance between production and sales. The first stage of contruction, progress of which can be seen in the illustration on the next page, comprises four units of Segas

plant, capable of a daily output of 20,000,000 cubic feet, but the site is planned for development up to at least three times this capacity.

The North Western Gas Board are now engaged, in conjunction with Messrs. Humphreys and Glasgow, on the design and construction of an initial gas unit with a capacity of 7,000,000 to 15,000,000 cubic feet of town gas a day at Partington, adjoining Manchester. The gasification system of this plant will comprise the production and purification of hydrogen of more than 90 per cent purity by the complete gasification of oil (and at a later stage coal) at the pressure of 400 lb per square inch with oxygen and steam and the use of this hydrogen in hydrogenating further oil (or coal) to produce gas at a high calorific value. This rich gas is then adjusted to the requisite calorific value by the addition of nitrogen from the oxygen plant.

The process employed to produce hydrogen is that of the Texaco Development Corporation, in which oil is gasified by reaction with steam in oxygen at high temperature and pressure. The resulting gas is a mixture of carbon monoxide and hydrogen, with a small amount of carbon dioxide and traces of methane. A controlled quantity of carbon black is formed, and it is removed from the gas by a water wash that simultaneously generates the steam necessary for reacting with the carbon monoxide to form hydrogen. The water wash is cooled, filtered free of carbon and returned to the system. The gas leaving the scrubbers of the Texaco installation is passed to the carbon monoxide conversion plant, where the shift reaction is carried out over a sulphur-resistant catalyst. The carbon dioxide and hydrogen sulphide in the gases, leaving the shift converters, are removed by absorption in a solution of potassium carbonate at a temperature of 120 deg. Cent., using the Benfield process. The absorbent solution is regenerated by reducing the pressure and stripping with steam, derived from the hot stream emerging from the conversion unit. The gas leaving the Benfield absorber, at least 90 per cent hydrogen at high pressure, is reheated and fed into the hydrogenation reaction vessel with preheated oil, which is converted at high temperatures essentially to methane, with a proportion of ethane. This hydrogenation reaction vessel forms the basic section of the entire process. The gases leaving it contain valuable high-purity benzene and highly aromatic compounds, which are removed by condensation and absorption in an oil circulation system and recovered for sale.

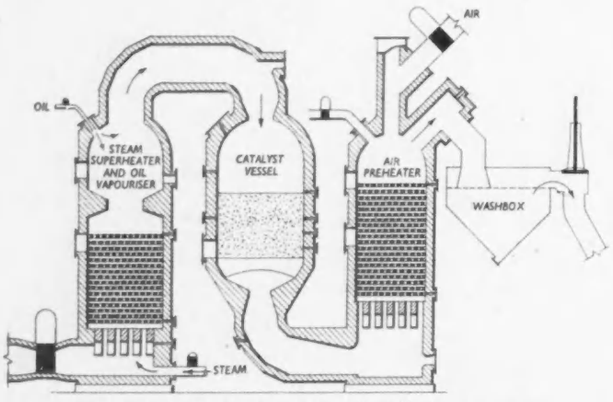
The South Western Gas Board is building a similar plant using a by-product of the oil industry at Bristol. One of the most important factors in this process is that the capital cost will be only one-third of that of a nuclear power station of the same heat output. This installation is to be commissioned in 1960.

This Texaco process operates continuously and produces no objectionable effluents, either gaseous or liquid. Future installations are reckoned to offer considerable financial advantages in production costs, maximum flexibility in raw materials, freedom from sulphur compounds and an almost non-toxic gas. The high pressure of the resulting product will ultimately result in lower costs by removing the existing expensive necessity of compression for long-distance transmission. This will enable future plants to be located economically for the transport costs of raw materials. In fine, in this process the gas industry has an opportunity to cheapen its production techniques, to procure its raw materials in the cheapest market and to offer its consumers an almost ideal piped fuel with still further improved service.

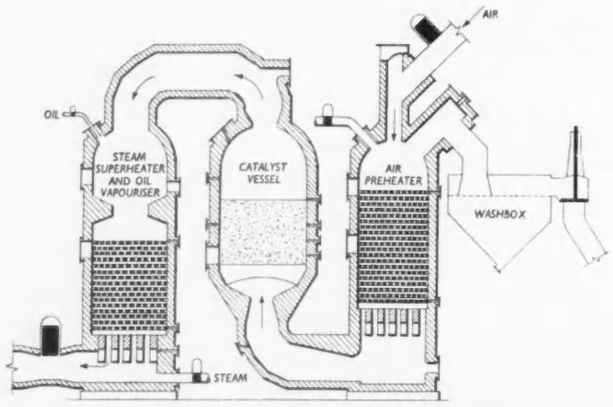
In July, 1956, an agreement was reached whereby the Southern Gas Board was to purchase 50,000 therms* of refinery gas a day from the Esso Company's Fawley refinery, and to enlarge Southampton gas-works to deal with this new raw material. The refinery gas is partly freed of sulphur compounds at Fawley itself, but the remaining sulphur impurities rendered it imperative to select a cast iron main with its greater resistance to corrosion than steel. The reforming of this gas by interaction with steam is to be carried out in two Onia-Gegi catalytic reforming units with a combined daily output of 16,000,000 cubic feet of finished gas, and with space for expansion to twice this scale. The cyclic operations are remotely and automatically controlled from a control room. The first two units went on stream last October (1958).

At Romford, only catalytic reforming is in operation, but the gas will also be used for the cold enrichment of blue water gas. The minimum scale of usage here is 70,000 therms of refinery gas a day, and plans are already complete for the acceptance of a further 35,000 therms daily of sulphur-free refinery gas from the Mobil Oil Company's processing plant adjoining Shell Haven. The combined immediate usage of refinery gas at Southampton and Romford totals 120,000 therms a day, and on conversion in catalytic plants enough therms of finished gas will be available to supply the domestic needs of a city with a population of 1,250,000. If this

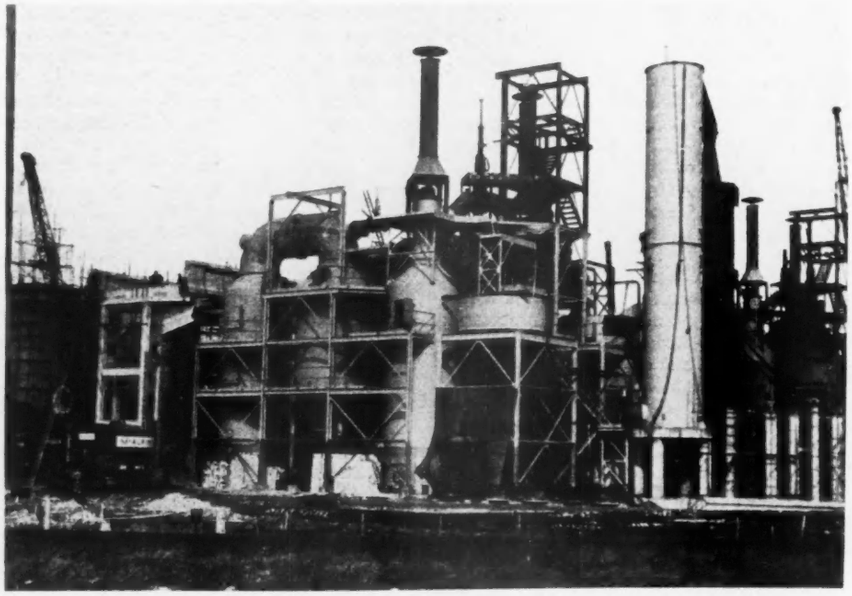
* A therm equals 100,000 B.Th.U.



Make cycle of the Segas catalytic oil gasification process



Blow cycle of the Segas catalytic oil gasification process



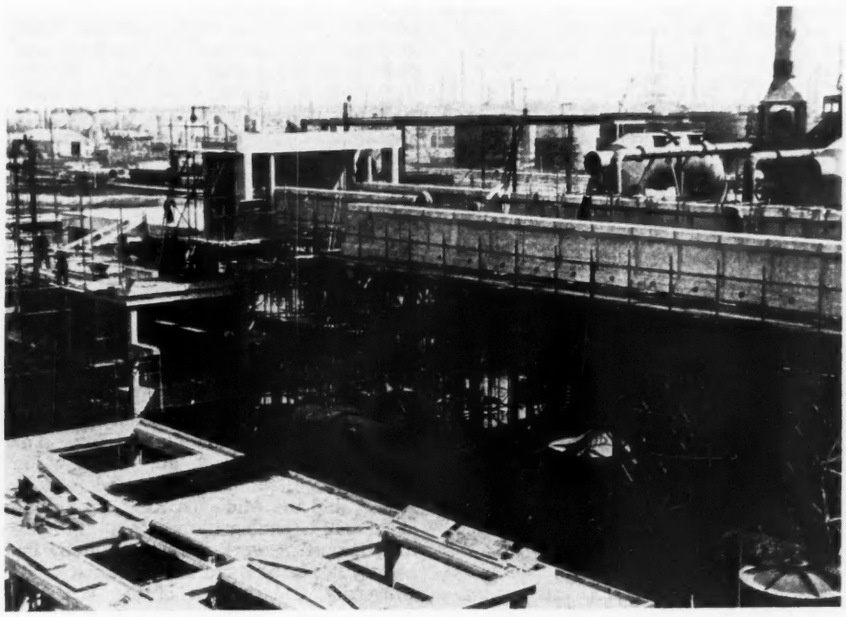
South Eastern Gas Board's Segas plant at Isle of Grain, on a site adjacent to the British Petroleum Company's oil refinery

displaces coal gas it will mean a saving of 500,000 tons of coal a year.

The construction of Britain's first Lurgi pressure gasification plant commenced at Westfield, Fife, on October 24, 1958, when the site was formally inaugurated by Lord Mills, Minister of Power. It will be built in two stages, the first scheduled for completion by July, 1960, when 15,000,000 cubic feet of gas a day will be produced, the second to be brought into operation in September, 1962, when the output will reach 30,000,000 cubic feet a day. The main contract for the new works was awarded to Humphreys and Glasgow, Ltd. In addition to the gas-making plant, it includes all civil engineering work and buildings, electricity generating plant and all other operations in erecting the works on a site which is now open country.

The coal to be gasified at Westfield is a low-grade open-cast material containing up to 25 per cent of ash and 16 per cent of moisture, and it is unsuitable for a traditional carbonising plant. It will be taken directly to the new gasworks by belt conveyor, where it will be crushed and screened and divided into two streams : that to be used in the gas generators being $\frac{1}{8}$in and $1\frac{1}{4}$in, and that destined for the boiler plant, for steam raising, being below $\frac{1}{8}$in. The coal is completely gasified in the Lurgi generators at a pressure of 25 atmospheres in a continuous stream of oxygen and superheated steam, the former being furnished by two air-separation plants. As all the carbon in the original coal is converted into gas, the residue is pure ash. The latter, collected from the gas generators and the boiler plant, will be returned to the open-cast workings. The heat contained in the crude gas from the generators will be employed to produce steam in waste heat boilers, and tar, oils, ammonia and benzole will all be recovered from the gas. The proportion of hydrogen in the gas is increased by a catalytic conversion plant and the carbon dioxide produced, together with that contained in the crude gas and the bulk of hydrogen sulphide present, are absorbed in a hot potassium carbonate solution in a Benfield unit. On leaving this plant the gas will have a calorific value of about 400 B.Th.U. per cubic foot. Enrichment by the hydrogenation of oil will raise this to 700 B.Th.U. per cubic foot, but before distribution the gas will be diluted with nitrogen, obtained as a by-product in the air-separation plants, to the normal calorific value of town gas, viz. 450 B.Th.U. per cubic foot.

Late in 1957, for the first time, consumers in any part of Britain took natural gas as part of their town's supply. It came from Cousland, near Dalkeith in Scotland, and the places supplied were Musselburgh, Cockenzie and Port Seton, Prestonpans and Tranent. The natural gas at Cousland has been formed in a bed of porous sandstone which is sealed off by a dome or anticline of non-porous rock. The average present productive depth of the well is 1600ft, or just under one-third of a mile. The main constituents of the gas are 94 per cent methane or associated gases, the remaining 6 per cent being nitrogen. The gas contains no sulphur. The calorific value of natural gas varies according to its constituents. The gas at Cousland has a calorific value of approximately 930–960 B.Th.U. per cubic foot (the declared calorific value of the gas manufactured at the Musselburgh works is 450 B.Th.U. per cubic foot).



Work proceeding on the concrete pipeline, instrument and control bridge which will span the Segas plant at Isle of Grain

At the well-head the natural gas pressure is approximately 620 lb per square inch, and the arrangement of the project is shown diagrammatically opposite. From the well-head the gas is led by high-pressure pipeline to a governor house, where the pressure is reduced in three stages from 620 lb per square inch to 3 lb per square inch, at which pressure it enters the 4in diameter main which conveys it 4 miles to the Musselburgh gasworks. The gas does not have the characteristic odour of coal gas, and consequently an odourising agent was added to it. It is not expected that the gas will contain water, but a water separator has been provided should water be present at a later date.

At ground level the well terminates in a 2in diameter tube surrounded by an $8\frac{3}{4}$in diameter casing. The 2in tube is surmounted by a collection of valves known as the "Christmas Tree," the star of the tree being a pressure gauge recording the pressure of gas in the well. One branch is the supply line which carries the gas to the high-pressure water separator, and the pressure-reducing valves, and so to the 4in diameter main leading to Musselburgh. Another branch is called the "burning line" and leads to a flare used for production testing. The total length of the main from the well-head at Cousland to Musselburgh is approximately 8400 yards, of which 3400 yards are of welded steel and the remainder of spun iron, the whole tested to 50 lb per square inch.

At the Musselburgh end of the main the natural gas passes through a governor to reduce its pressure to that of the coal gas manufactured at the Musselburgh works, and after passing through a meter it joins the coal gas stream. The mixture is then measured and passes into a gasholder for storage before distribution. There are four instruments to measure the calorific value of the coal gas, the natural gas, and the mixed gas entering and leaving the gasholder. A gravitometer is fitted so that the specific gravity can be recorded at any of these four points. Remote control instruments at Musselburgh also show the pressures in the governor house at Cousland and the flow meter readings.

After several years of trials a methane drainage scheme was completed in 1958 for three collieries in or adjoining the Afan Valley in South Wales. The three pits are Avon, Glyncorrwg and Duffryn Rhondda, and the valley lies north-east of Port Talbot. Underground pipelines bring the gas to surface pumping stations. At Duffryn Rhondda colliery there are more than 5 miles of underground piping and over 2 miles of it at each of the other collieries. Surface pipelines from Avon and Glyncorrwg link up and, at a more southerly point, join a pipeline from Duffryn Rhondda to serve a main pipeline stretching for more than 10 miles along the vale to Wales Gas Board centre at Aberavon near Port Talbot. Along the main pipeline the gas from the pits passes at the rate of 1,000,000 cubic feet a day. This, after treatment and dilution at the Aberavon centre, is equivalent to 2,000,000 cubic feet of public service gas, sufficient to meet the daily needs of a town of 43,000 inhabitants. The projected extension of underground workings at the three collieries will greatly increase the quantity of gas for public service. The incidence of methane varies considerably from pit to pit according to the district and nature of the coal. By this scheme the fire damp dreaded by miners is drawn away from the coal measures and taken to the surface to be brought into public service in industry and home.

Speaking to the Oil Industries Club, London, way back in 1947, Mr. (now Sir Stephen) Gibson affirmed that there was no basic difficulty in transporting liquid methane, and predicted that tankers would, in due course, be designed to carry it across the world. To-day his statement has come true. The experimental ship "Methane Pioneer" discharged late in February its cargo at the Canvey Island marine terminal.

For several years past a group of scientists, supported by the Union Stockyard and Transit Company of Chicago and the Continental Oil Company, have been working on this problem. From the outset they considered that Britain, fuel-hungry in the context of great post-war industrial expansion, would be the best customer ; and the natural medium for that market is the gas

industry with its capital already available in the shape of a vast distribution network. At the same time the North Thames Gas Board, with the largest sales of gas, was for geographical reasons faced with high-priced indigenous raw materials for gas-making. Therefore, it started investigating the economic implications of importing liquid methane to London. Meantime, the British Gas Council decided to join with Constock (a joint corporation owned by Union Stockyard and Continental Oil), in preparing a trial ship on the plans developed by this company. Experiments were undertaken on land to gauge the effect of the transportation of liquid methane, and every possible effort was made to simulate the hazards of the sea. These included impact and vibration tests on tanks filled with 50 tons of liquid nitrogen.

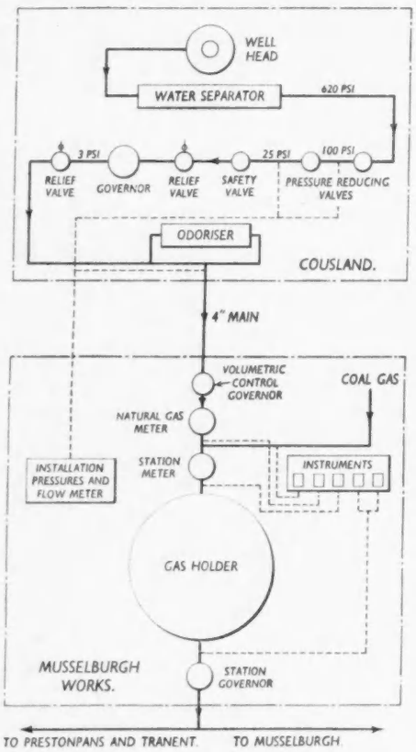
Two major difficulties faced the designing of a satisfactory ship to carry methane gas in a liquid form : the contraction imposed by a liquid of approximately −258 deg. Fah. in the tanks, and the stability of tanks within the ship's structure under these conditions while still maintaining good heat insulation. There was also the difficult problem of materials that will retain stability and strength at this low temperature. Cargo handling, too, presented unusual features, not only because of the low temperature, but because the material is actually boiling.

The converted ship has five tanks with a total capacity of 2000 tons of liquid methane. This gas, having been reduced to the liquefying temperature at a shore installation, will be pumped into the tanks. The maintenance of the very low temperature of the liquid rests on the efficiency of balsa wood packed round the tanks as an insulant. As the cargo is light for its bulk, and balsa wood is similarly light, the modifications to the ship posed some intricate problems, and a good deal of ballast has had to be carried to render her seaworthy. It is inevitable that on the journey some of the liquid will vaporise into methane gas, but this is not expected to exceed more than ½ per cent a day and it will be allowed to blow waste. The interesting proposition has been put forward that in the specially built methane tankers visualised for the future, the " boil off " should be employed to drive the ships' main engines.

Turning to the gas-making site of the North Thames Gas Board on Canvey Island, equally stringent precautions have been taken to prevent uncontrolled boil off by insulating the liquid from the outside temperature. For the preliminary trial, two tanks, each 65ft high, with an outer steel shell and an inner aluminium container, to hold 1000 tons of liquid methane, are being used. In these an intumesced volcanic rock powder, occupying the space between the inner and outer skins of the tanks, provides the necessary insulation. This is reckoned to be more effective than balsa wood but the light rock dust would prove unsuitable for insulation in a ship because its movement would cause the material to " bed-down " and lose efficiency. The liquid was taken from the ship to the tanks through a 10in pipeline with a 6in insulating covering, and the associated valves and pumping system were similarly protected against cold loss. It is destined for Romford and the North Thames gas grid.

If this trial proves a success it will benefit the British gas consumer in many ways. In the first place, one must assume that the scale of ship will be very much enlarged to reduce costs. The economics of transporting refrigerated liquid depend on the ability to keep it cold, and the loss through boiling off is affected by the free surface area of the vessel containing it—the larger the tank the less the proportionate warming area. Therefore, it is envisaged that 30,000-ton deadweight tankers will be built, carrying the equivalent of 2000 m.c.f. of town gas of 500 B.Th.U. With two or three such vessels Britain should begin to witness the arrival of an impressive volume of gas, which cannot fail to stem present inflationary cost trends and, in the long-term, provide a cheaper gas supply.

Once an adequate supply has been assured, it would no longer be necessary to reform the



Natural gas project : Cousland-Musselburgh

gas, but it would be feasible, after adjusting consumers' appliances, to distribute it, as is done in the U.S., as a gas of 1000 B.Th.U., in which form it is non-toxic and sulphur-free. Moreover, the saving on the reforming would amount to a cost reduction of at least 1d. and possibly 2d. a therm (100,000 B.Th.U.)—a welcome stimulant to sales in both the domestic and industrial fields.

One further point emerges, and it has not been taken into account in any of the present calculations. There is a valuable thermal asset in a liquid at −258 deg. Fah., and there are a number of processes in the chemical industry which could use this negative heat energy while leaving the methane as intrinsically valuable as it was when it left the oil-field half-way across the world.

The North Thames Gas Board owns land on Canvey Island with a river frontage to which large tankers may be brought. It also concluded an agreement to purchase large quantities of tail gases from the refineries at Shell Haven and Coryton near Canvey Island, and is laying a pipeline from these plants to Romford, where the gases will be converted to town gas. The plant installed at Romford, for the reforming of the tail gases, is suitable for gasifying distillate oil. Thus, this board is doubly assured of continuity—gas supplies with the alternative of oil. When one considers the waste of energy in the form of flared natural gas going on all over the world to-day, particularly in the Middle East and Venezuela, one must admit that the prize is worth trying for, especially by energy-hungry Britain. It was therefore an exciting day when the first trial tanker (" Methane Pioneer ") was moored alongside the windswept Canvey Island estuary on February 20. This proved an outstanding success, and the Methane Pioneer, according to the British Gas Council, will make two or three more voyages.

With decrease in available good carbonising coals, research and development of the Gas Council has mainly been switched to techniques for making gas from low-grade coals, especially high-ash fine coals, and to processes employing alternative raw materials. This opened up the entire vista of complete gasification of coal, gasification of a wide range of oils, treatment of refinery tail gases and use of imported liquid methane. Each of the different methods of preparing gas poses its own research problems. As with traditional techniques, there are the usual ones of purification, effluent disposal and utilisation of the products, but to these are added more specialised considerations such as the handling at high pressure, mechanism of catalytic reactors and an understanding of the combined characteristics of new types of gas.

The total research outlay of the British Gas Council is allocated thus : 50 per cent on gas manufacture, 25 per cent on purification and effluent disposal, and 25 per cent on utilisation. Following years of exploratory work its objective relates to the establishment of the hydrogenation process for making gas, and for coping with all the ancillary problems of purification, distribution and use. The main research centres are the London Research Station at Fulham and Watson House, and the Midlands Research Station at Solihull adjoining Birmingham. In addition, important work is carried out by the Livesey Professor in his laboratories at Leeds University, and by four of the Area Gas Boards.

The Fulham Laboratories deal with every aspect of the manufacture and purification of gas by the conventional processes, and by the newer techniques at pressures near to atmospheric. Watson House is concerned with all problems arising out of the utilisation of gas and coke for domestic and industrial purposes. The Midlands Research Station has as its main province the development of processes for the manufacture of gas at high pressure, the most important of which is that of hydrogenation of coal. In addition, investigations are under way on developing techniques based on the Lurgi process for the gasification of coal in steam and oxygen. The Livesey Professor at Leeds is engaged on both laboratory and full-scale experiments on the effects of ammoniacal liquor constituents in sewage treatment processes. Work on the biological treatment of this liquor is prosecuted at the London Research Station. Academic studies of flame structure and heat transfer from flames are in progress at Leeds University, and close liaison is maintained with the more practical work being done in this field at Watson House.

The number of British gasworks at the end of March, 1958, was 536 (seventy-five of the smaller ones were closed during 1957–58). This is almost half the number at the vesting date, but the capacity had been stepped up by nearly 25 per cent. The capacity of the industry in March, 1958, was 12,000,000

therms a day. The longest gas grid in the United Kingdom, stretching 295 miles from Evesham, Worcestershire, to Penzance, Cornwall, was completed last October. Integration in the South-West region permits interchange of gas between twelve modern gasworks costing £5,000,000. The Gas Council is paying particular attention to the economics of building a national gas grid. In his presidential address to the Institution of Gas Engineers, Mr. J. Burns, chief engineer of the North Thames Gas Board, suggested the construction of a London–Manchester gas main to take advantage of the fact that 70 per cent of the total gas produced in Britain is consumed in the belt of the country within 35 miles of either side of a line between these two cities. The greatest concentration of gas usage is in the London, Midlands and South Lancashire areas. Such a gas main joins up two important oil receiving and processing areas, and also passes through, or in close proximity to, the biggest low-rank coal-producing area in the country. During 1957–58, work began at eleven new oil gasification plants, making twenty-five in operation and fourteen more were planned. The gas industry estimates that its consumption of tail gas and other refinery surpluses might go up in terms of coal equivalent from the January, 1959, level of 500,000 tons to 2,000,000 tons by 1965.

Production of "New Metals"

Over the past few years some £10,000,000 has been spent by Imperial Chemical Industries, Ltd., on the development of "new metals" production. This work has included the commissioning of plants for the production, melting and fabrication of titanium, beryllium and zirconium as well as a programme of research into hafnium, niobium and vanadium. In the course of a recent press visit to the I.C.I. Metals Division at Witton, Birmingham, we were given a general insight into the progress which has been made and the development work in hand.

TO meet the urgent demands for metals with new and exacting properties, particularly for the aircraft and nuclear engineering industries, the Metals Division of Imperial Chemical Industries, Ltd., has spent some £10,000,000 in developing the production of what are termed "new metals." This work has included the commissioning of this country's first titanium melting and fabrication plants, its largest zirconium plant and the first wrought beryllium plant in Europe. In addition to an extensive programme of research with these metals investigations are in progress with others which are still newer—in particular, hafnium, niobium and vanadium.

The properties of titanium, which is produced in six commercially pure grades by I.C.I., have been given from time to time in our columns. These properties have made it particularly suitable to meet the needs of the aircraft industry for a light alloy which could meet the strains and exigencies imposed by ultra-high-speed flight. It has an exceptionally high strength/weight ratio which is retained at temperatures higher than are considered safe for aluminium alloys, and satisfactory creep properties can be attained at temperatures as high as 500 deg. Cent. The fatigue ratio of titanium and titanium alloys is appreciably higher than that of most non-ferrous metals. Commercially pure titanium has a low density and will withstand moderate temperatures for long periods or high temperatures for short periods, whilst its resistance to attack by sea water, fuels, hydraulic fluids and solvents makes it suitable for applications where immunity to corrosion is important.

For the chemical and electro-chemical engineering industries titanium has very useful properties in its outstanding resistance to corrosion and erosion in a wide range of aggressive media, such as nitric acid, aqua regia, chlorine, metallic chlorides and organic acids. Anodes made of titanium with an extremely thin coating of platinum can carry very heavy anodic currents, offering the advantages of platinum at much lower cost. Titanium-platinum anodes are now in use in electrolytic cells for chemical manufacture and for the cathodic protection of chemical plant and marine structures. The metal is completely inert in hot or cold chromic acid, nickel plating solutions and most other liquors used in metal finishing. Finally, titanium and some of its alloys, having an extremely short "half-life," are particularly suitable for certain components in nuclear reactors, such as handling gear and control rod sheaths.

Titanium Production

The firm's interest in titanium began with the decision to build a Kroll plant with a capacity of 12 tons a year in 1949 in order to acquire experience in melting and fabricating the metal. This process is based on the reaction of titanium tetrachloride with the metal magnesium. This yields titanium mixed with magnesium chloride, which has then to be removed by distillation under vacuum.

The initial Kroll plant went into production in 1951 and it was replaced by a 100-ton capacity plant three years later. Investigations were being carried out at the time into the possibility of developing a cheaper and better method of producing titanium based on reduction by sodium. As a result of these investigations a full scale reduction plant was built and commissioned in 1955.

This plant was designed to produce 1500 tons a year of raw metallic titanium, in the form of dull grey granules, quite different in appearance from the coke-like cobbles of Kroll sponge.

Titanium cannot be turned into massive form by normal casting methods, and it has a very high melting point—nearly 1700 deg. or 200 deg. Cent. higher than that of steel. This would not be an insuperable problem if, in its molten state, titanium did not combine with any of the materials normally used to make or line a high-temperature furnace. Moreover, molten titanium absorbs gases, notably oxygen or hydrogen, which affect its physical properties and lessen its usefulness as a structural metal.

Before titanium could be worked, then, some very special plant and techniques had to be devised. The first difficulty—that of the high melting point—was overcome by using the intensely high temperature of a powerful electric arc within the furnace. The problem of containing the metal while it melted was solved by using a water-cooled copper crucible which "froze" a skin on the outside of the molten mass, that of contamination by excluding air altogether, melting either in vacuum or in an inert gas.

Although the same basic method is still used, titanium melting to-day is vastly different from what it was in 1955 when the plant at Witton was commissioned. Then, the size of ingot was limited to 400 lb in weight and eighteen furnaces were needed for an output of 1500 tons a year. Now, 2000 tons a year can be produced in ingots weighing 2100 lb or 4200 lb—and by just three furnaces. These furnaces, which were described in our issue of June 6, 1958, were built in Western Germany.

Because titanium melting is subject to hazards not encountered with more conventional metals, all operations are carried out by remote control. Each furnace is built inside a massive 60ft high reinforced concrete cubicle, and before melting starts this is sealed by closing and locking a 10-ton door, so that even in an emergency there is no risk to plant personnel.

In the titanium melting practice used, a consumable electrode—i.e. one which is itself made of titanium—is melted to form the ingot. This electrode is made from granules of raw metallic titanium, sometimes mixed with other powdered metals to make alloys. After double mixing to ensure thorough blending, a measured charge is fed into the die of a 2500-ton press, which compacts the powder into a semi-cylindrical briquette. Briquettes are then welded together to make an electrode 12ft long and weighing almost a ton. As shown in one of our illustrations, the electrode is suspended from the top of the furnace while the water-cooled crucible is clamped on at the bottom. The furnace is evacuated, an arc is struck on to a small quantity of titanium powder in the crucible base and the whole electrode is slowly melted to form an ingot. To ensure complete homogeneity, the process is repeated. The ingot is raised to the top of the furnace, the crucible changed and the ingot remelted into a larger-diameter crucible.

The progress of melting is watched in the control room through an optical system which projects an image of the arc zone on to twin screens. Electrical and electronic devices supply continuous data on the operation of the furnace and ancillary equipment throughout the four or five hours needed to produce a 1-ton or 2-ton double-melted ingot.

Once the metal has been consolidated into ingot form, conventional metal-working techniques can be used, provided that attention is paid to titanium's inherent characteristics, such as oxidation behaviour, low rate of work hardening and tendency to gall on sliding contact. After an ingot has undergone ultrasonic testing to ensure freedom from flaws, it is passed to the forge for hot forming into flat slab or round billet. By shot-blasting and machining, the dull outer layer of the forged product is then removed to impart the characteristic silvery sheen of the wrought metal.

Most of the titanium produced in the Witton plant goes to the fabricating plant at Waunarlwydd, South Wales, where specially adapted rolling plant completes the processing of rod, sheet and tube. This plant was

described in our issue of June 27, 1958. Other wrought forms—wire and extruded sections—are processed on plant normally used for conventional non-ferrous alloys.

Zirconium

The main uses of zirconium are in nuclear engineering, by reason of three properties—it is one of the few metals which, when used in a nuclear reactor, absorbs comparatively few neutrons ; it has good mechanical strength at room and moderately elevated temperatures ; and it is compatible with uranium fuel up to a high temperature. Zirconium is a silver-grey metal with chemical and physical properties similar to those of titanium, but its density is about one-and-a-half times greater. Zirconium alloys have been developed with outstanding corrosion resistance to water and steam at high temperature and pressure. This property, combined with their high mechanical strength, has led to the extensive use of the alloys for fuel sheathing and core components in pressurised water and boiling water reactors.

In Britain, notably in the research laboratories of Metropolitan-Vickers Electrical Company, Ltd., zirconium alloys resistant to corrosion by carbon dioxide have been developed. These alloys are suitable for service up to about 500 deg. Cent., and are useful for components such as fuel element supports, tubes for control devices, flexible hose, packing pieces, &c. Outside nuclear engineering, zirconium at present has few uses, but they are important. It is a highly corrosion-resistant material, in a few respects—notably in concentrated hydrochloric acid, intermediate concentrations of sulphuric acid, oxalic acid, phosphoric acid and fused caustic soda—more so even than titanium.

Raw zirconium in sponge form is extracted from beach sands containing the silicate zircon, by chemical processes generally similar to those used to extract titanium. A complication is, however, that a sister-metal, hafnium, occurs naturally to the extent of 1 to 2 per cent in all zircon deposits. Because this hafnium readily absorbs neutrons, it has to be separated from the low neutron absorber zirconium when the latter is to be used in a nuclear reactor. This is done in the course of the extraction process and produces " reactor grade " sponge. The presence of hafnium does not affect the mechanical properties of zirconium and, where low neutron absorption is not critical, hafnium-bearing sponge can be used.

The difficulties encountered in melting zirconium are very similar to those found with titanium. Its melting point is even higher (1852 deg. Cent.) and its intense reactivity, particularly when molten, precludes the use of conventional furnaces and refractory-lined crucibles. With the experience gained in producing titanium, the Metals Division of I.C.I. had surprisingly little difficulty with zirconium, which went into commercial production in 1958. Ingots weighing half a ton are produced by the consumable electrode vacuum arc melting process and, if required, ingots weighing up to 3 tons can be produced.

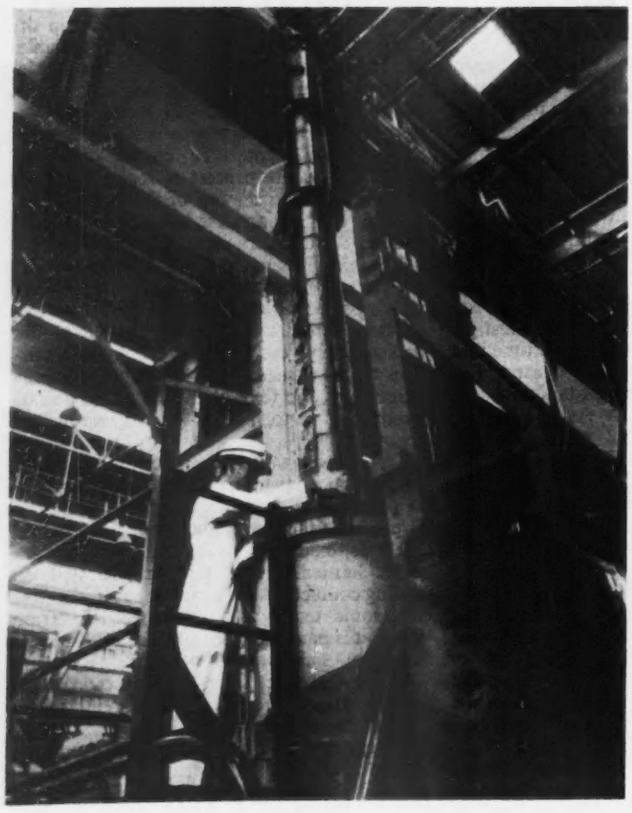
Ingots are converted into wrought forms—strip, sheet, plate, rod, tube and wire—by conventional processes, though precautions must be taken to avoid contamination during hot working and annealing, particularly by nitrogen, which impairs corrosion resistance.

Beryllium

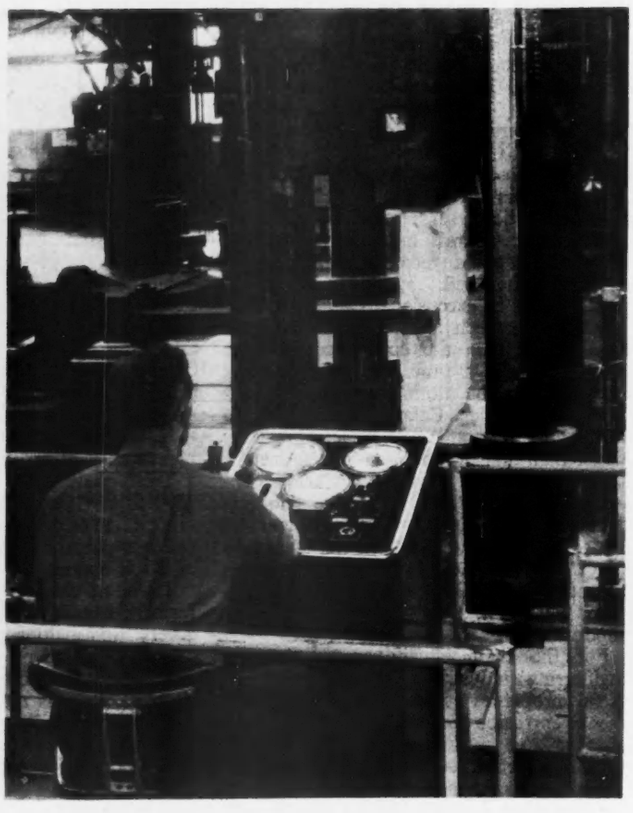
In some ways, beryllium is not a new metal; it has been used for many years in the production of beryllium-copper. What is new is the relatively large-scale production of pure beryllium in wrought forms. Its extraction from the ore, the semi-precious stone beryl, is a laborious and costly process ; special techniques are necessary to overcome technical difficulties at every stage of production and to eliminate the toxic hazard which powdered beryllium and its salts may present. The demand for beryllium arose in this country when forward planning by the United Kingdom Atomic Energy Authority revealed the need for a new fuel sheathing material.

Metals used for fuel cans must fulfil very exacting requirements. In all reactor operating conditions, the can must safely contain the fuel and dangerous radioactive fission products ; be compatible with both the fuel and the coolant ; be as " transparent " as possible to neutrons ; and allow efficient transfer of heat to the coolant. In current gas-cooled reactors, special magnesium alloys provided the answer. But the next steps in improving the efficiency of gas-cooled reactors involve operating at much higher temperatures—perhaps up to 600 deg. Cent. against the 450–470 deg. Cent. of current gas-cooled reactors. At these temperatures magnesium alloys are not suitable, so a metal was needed which not only had all the useful properties of magnesium alloys, but retained them effectively at much higher temperatures. Of all the metals evaluated, beryllium was much the most promising, and the U.K.A.E.A. therefore specified this metal for use as fuel sheathing in its experimental advanced gas-cooled reactor.

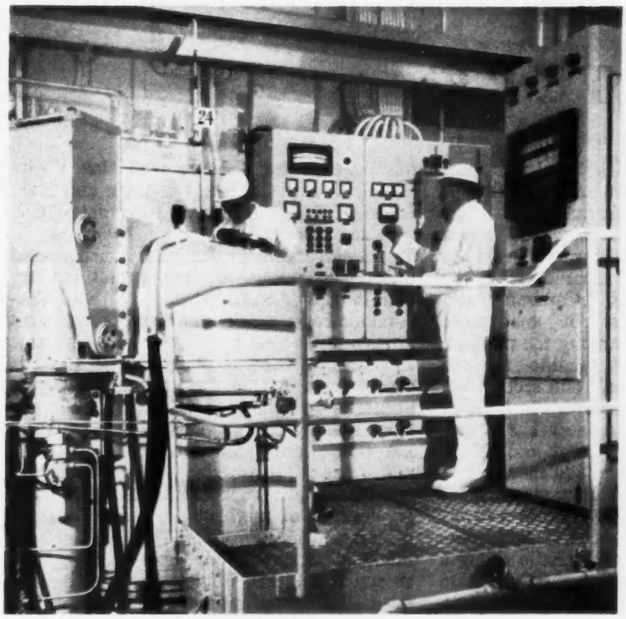
From a nuclear viewpoint the most important properties of beryllium are its high strength at elevated temperatures, good corrosion resistance to carbon dioxide and a very low neutron absorption cross-section, which is less than half that of



Loading a 2100 lb titanium consumable electrode into crucible prior to melting



Forging a titanium rolling slab on a 1500-ton press, using mechanical handling and manipulation equipment



Beryllium powder, produced by reducing the cast ingot, is consolidated in this sintering furnace prior to extrusion

Ingots of beryllium being reduced to chips on a " glove boxed " lathe

magnesium, the most effective neutron-transmitter in common use. In addition, it has a very low density, a high elastic modulus and good thermal conductivity. The metal has, however, poor ductility which at the moment can only be improved by employing powder metallurgy techniques during early stages of processing. This necessity complicates production both directly and indirectly, because powdered beryllium can affect the lungs if inhaled in excessive amounts, and special precautions must be taken to ensure that personnel are not exposed to this risk. The problem is essentially one of dust control. The safe level of atmospheric contamination adopted for the Witton plant, determined as a result of more than ten years' experience in U.S. and U.K.A.E.A. plants, is 2 microgrammes per cubic metre.

Beryl, the principal source of beryllium, is an aluminium beryllium silicate generally yielding about 3½ per cent beryllium. Metallic beryllium is separated by a three-stage extraction process. The ore is converted into a chemical compound, beryllium hydroxide, and this in turn into beryllium fluoride or beryllium chloride. Pure metal is extracted either by reacting the fluoride with magnesium, which produces " pebbles," or by electrolysis of a mixture of beryllium and sodium chloride, which yields " flake."

The I.C.I. plant, which uses as its raw material imported flake and pebble beryllium, is designed to operate as a research production unit with an initial output of about 7 tons a year.

It is housed in a single-storey building, broadly divided into contact areas, where beryllium is handled, and non-contact areas free from beryllium.

The production area, laboratories and ventilation bay, all contact areas, are designed to simplify dust control. There are no windows and the incoming air, filtered and heated, is changed every three minutes and extracted through machine enclosures, glove boxes and special ducts. About 200 tons of air are moved every hour and passed through absolute filters before being discharged from a 150ft chimney. A negative pressure created inside the building by the ventilation system ensures that all contact air follows the prescribed route through the exhaust filters, keeping adjacent areas free from possible contamination.

Two factors complicate the consolidation of beryllium flake. First, properties of the wrought metal are adversely affected by impurities present in the raw material, so that refining in a vacuum induction melting furnace is an essential preliminary. Secondly, even vacuum-cast beryllium has a very large grain size and is extremely brittle. To produce metal with superior mechanical properties, particularly in regard to ductility, powder metallurgy techniques must be employed. For this reason, the cast ingot is machined to swarf, which in turn is ground to fine powder. This powder is then packed into graphite moulds and sintered at high temperature under vacuum. Solid compacts produced in this way are either machined to finished size or prepared for further processing. Rod and tube are produced by extrusion during which seizing in the dies is avoided by plating the extrusion slug or enclosing it in a protective mild steel sheath.

Careful design of equipment handling powdered beryllium ensures that air contamination is kept within the prescribed limit. Suction pipes working with a velocity of 10,000ft per minute are provided immediately adjacent to cutting tools or other points of dust generation, and all machining operations are performed inside glove boxes from which air is automatically withdrawn. Our illustrations show some of the equipment used in the new plant.

In addition to its work of supplementing and developing further the activities of the production of the metal division the large research section at Witton is carrying out long-term research into other metals likely to play an important part in nuclear engineering. In this department a prolonged and comprehensive evaluation of new metals is carried out to determine methods for their consolidation and processing to required shapes. Amongst the metals at present undergoing evaluation are hafnium, niobium and vanadium.

Evaluation is carried out initially on very small buttons, weighing perhaps as little as ½ oz, produced in special miniature furnaces. When results are satisfactory, progressively larger melts are processed in various types of vacuum furnace. The arc melting laboratory has facilities for producing buttons weighing up to 100 grammes and ingots weighing from 5 lb to 300 lb. At every stage, the consolidated metal is subjected to exhaustive chemical, physical and mechanical testing, its deformation characteristics are studied so that suitable rolling, extrusion and drawing techniques can be established, and close attention is paid to any problems relating to machining and jointing the wrought product.

Catterick By-Pass

LORD CHESHAM, Joint Parliamentary Secretary to the Ministry of Transport, opened the Catterick by-pass on December 11. The by-pass is 3½ miles long, and diverts traffic from Catterick village and Catterick Bridge on the Great North Road. The new road leaves the A.1 near Catterick R.A.F. station and rejoins it near Gatherley Castle. Between roundabouts at the two junctions it is carried under or over all side roads.

The road is 80ft wide, with dual 24ft carriageways, flush concrete edges and hard shoulders. There are ten bridges, seven of them constructed of broad-flanged universal beams. The bridge over the River Swale is the largest and consists of a three-span structure having a central span of 75ft and two side spans each of 54ft. The bridge designs were approved by the Royal Fine Art Commission which also advised on the ashlar masonry facing, used on all the bridges.

The line of the by-pass crosses the site of the Roman fortified town of Cataractonium, on the south bank of the River Swale, where the road runs through a deep cutting. Before the road was built, the site was excavated by a team of archæologists and discoveries of much interest were made, including well-preserved Roman public baths and ancillary heating chambers ; it was not possible to preserve them.

Catterick by-pass was completed in twenty months, at a cost of about £1,000,000. It is stated by the Ministry of Transport to be a link in the chain of major improvements now in hand on the A.1 between London and Edinburgh. In addition to the by-pass, 13 miles of the existing trunk route in the North Riding of Yorkshire have been converted into dual carriageway road since 1956, at a cost of over £1,000,000. The North Riding County Council, acting as agents for the Ministry of Transport, has carried out all these works, including the Catterick by-pass, by its direct labour organisation under the supervision of the county surveyor, Mr. R. Sawtell, A.M.I.C.E.

LITERATURE

Jane's All The World's Aircraft 1959–60. LEONARD BRIDGMAN and JOHN W. R. TAYLOR. Sampson Low, Marston and Co., Ltd., Potter Row, Great Missenden, Bucks. Price 105s.

"THIS is the Golden Jubilee Edition," we learn on lifting the front cover, and it includes a chronology of 1909, listing such events as the decision of the British War Office to cease making experiments with aeroplanes as the cost proved too great. Engineers also were thinking in ways recognisable to-day, as is evidenced in the reproductions of thirty-two pages of the 1909 *All The World's Airships* (*Aeroplanes and Dirigibles*): the Breguet-Richet II bis biplane-helicopter inclined its propellers at 40 deg. "for rising" —however, the propellers themselves would terrify to-day, having four blades which each resembled one bay of a biplane, so that sixteen aerofoils were thrashing the air. Jane made no "Remarks" on this device, although he was wont to make good use of that heading: "Cody (British Government) Biplane—This machine was originally somewhat different, but altered to the details here given after a smash." Even then, one suspects, the compilers had less than absolute co-operation from constructors: it is not altogether clear what was meant by saying that the wings of the Gregoire-Gyp were 'Actuated on the "differential" system of motor cars': would that one could still buy an example for £1000 and find out!

After the death of the founder in 1916, "Jane's" was edited by C. G. Grey, raconteur and controversialist extraordinary, though hardly meriting the epithet "incorrigible." The present editor, Leonard Bridgman, joined C. G. G. forty years ago, in time to work on the $6\frac{3}{4}$ lb 1919 issue that he terms "monumental": certainly there was ample matter in that first post-war volume to fill the 681 pages. (For instance, that year, the Atlantic was crossed by air for the very first time, and four pages were devoted to the achievement of the United States Navy—it is interesting to reflect that, right up until this year, the "glamour" has been accorded to the machines able to make the crossing non-stop.)

Now it has been announced that Mr. Bridgman has retired as Editor, although remaining on the board of the publishers, and that the forthcoming editions will be the sole responsibility of John Taylor.

The latest edition has a mere 557 pages, the compilers having felt obliged to drop the last vestiges of the "Historical Sections," i.e. the Military Aircraft Markings and the Airlines of the World. One alteration that cannot be welcomed is the omission of the records currently recognised by the F.A.I.: few, indeed, are the reference books that attempt to encompass such relatively difficult information, and it used to be reassuring to think that at least once a year an up-to-date compendium was prepared. The volume now has four sections, "Aeroplanes," "Guided Missiles," "Aero Engines" and "Airships," and four indices, "Aircraft," "Rotary Wing Aircraft," "Guided Missiles," and "Engines": it remains to be seen how the compilers will classify the ornithopters of which we are beginning to hear. The somewhat artificial division between turbine and piston engines has now been wiped away, and one sees signs of that between aircraft and missiles being threatened, for many target and reconnaissance drones fit ill with the man-carrying machines.

It cannot be pretended that 1959 was a vintage year for aeroplanes: many machines are conspicuous by their absence from the pages, such as the Miles "Caravan" and the Bristol 205. Most of the more exciting appearances are among the missiles, including the Lockheed satellite for the "Discoverer" programme. This section can be recommended to any observer who believes that the United States engineer has a predilection for insupportably large and expensive weapons: it gives details of the Convair "Lobber," able to place 50 lb payloads more than 5 miles away and be 70 per cent recoverable, and the Ford (Aeronutronics) "Shillelagh," a 40 lb close-support missile riding a microwave beam. Unfortunately, the section has no details of Soviet air-to-air missiles, although some of the fighters are described as carrying infra-red homers: in contrast, radar-guided missiles capable of collision interceptions are described among both French and United States weapons.

Many of the new appearances among the aircraft are light aeroplanes built in the United States and not in commercial production: some of these come in for indirect comment, such as the B-B "Midniter": "The Midniter was built without the use of drawings, so no plans are available." In the esoterically named "Kee Bird," intended naturally enough for use in Alaska, "the seats are easily removable, providing a clear flat floor on which the pilot and passengers can sleep during flights to remote areas"—not, we trust, in V.F.R. conditions. One wonders also whether it was, as stated, to save weight that no electrical system is used, or because the batteries could not be kept from freezing. In some cases one feels more seriously at issue with the compilers: can they really picture a Do. 29 with turbo-jet engines, even if propellers tilting downwards do seem sharply at variance with the precedent set by the Do. 26? As often before, we feel that artist's impressions are too numerous, being redundant when a three-view drawing is provided, or even undesirable when, as in the case of the Boeing 720, the distinctive details, such as the negative camber at the root, are obscured rather than illustrated: this seems inconsistent with the refusal to print even a picture of a recognition model of such an important and distinctive machine as the "Backfin" supersonic medium bomber.

The engines section includes some surprisingly informative pictures, such as those of an all-steel "Super Atar" for flight at Mach 3, showing two rows of variable incidence stator blading and an enormous variable nozzle, and of a power plant for a Canadair-Convair 540 showing the Napier "Eland" and a Blackburn-Turbomeca "Artouste" snuggled together in front of the fire wall. In at least one case the picture is the sole source of essential information, for it is not stated that the Mark III Turbomeca "Turmo" has an axial low-pressure compressor.

It is interesting to note that, for "Jane's," "aircraft" includes ground effect machines; this issue has details of two, the Saunders-Roe "Hovercraft" prototype and the Curtiss-Wright "Air-Car."

Mathematics for Telecommunication Engineers. By S. J. COTTON. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 37s. 6d.

THERE are many professional journals and periodicals, published both in this country and in the U.S.A., which deal with telecommunications. To an increasing extent articles on various aspects of this wide subject have become more mathematical in character so that the reader cannot properly understand them, or possibly is discouraged from reading them, unless he has sufficient knowledge and ability to cope with the mathematics involved. In addition the communication engineer has to-day to make greater use of mathematics in the conduct of his normal work. The standard of mathematics required, except for some specialist subjects, is not high; but it is beyond the level attained in most of the popular courses of mathematical education. The need for a textbook on mathematics to meet this requirement, "to bridge the gap" as he says, has been appreciated by the author of this book. Its usefulness has been greatly extended by the inclusion of sections specifically for students taking examinations. Realising that the practical engineer may have no interest in the more academic aspects, the author has throughout the book annotated the special sections which are primarily for the student, and has segregated some theorems and proofs in appendices. By these artifices the book has been written to serve two functions.

An examination of the contents of the book shows a convenient division into three parts: general mathematics, mathematics particularly required for normal telecommunications, mathematics needed for more specialised branches of the subject. The first part is contained in the first four chapters and is in the nature of a revision of the algebra, trigonometry and calculus as a basis on which to develop the mathematics required for the rest of the book. Determinants are treated in the second chapter: but there is no mention of matrices. For some time it has been the practice to express the linear parameters of a four-terminal network in matrix form, and it is now becoming more widespread with the increased use of transistors. An example of the dual function of the book is the inclusion in the chapter on series and expansions a section on convergence of series which is asterisked to denote that it is of interest mainly to examination students.

A chapter on complex functions starts the second part of the book. Although it is explained how an oscillating function can be expressed both as a vector and in the exponential form, no mention is made of the common practice of expressing a sinusoid as the real part of a complex number, or of the extension of this device for the calculation of power in alternating current circuits. The standard methods of integration and the solution of elementary differential equations are covered, with their application to transmission lines and simple networks. There is a brief reference to attenuators and filters in the same chapter and an appendix which further extends the treatment.

It is halfway through what has been termed the second part of the book—and incidentally at about the middle of the whole book—

that there is a sudden demarcation both in the subject matter and treatment. Up to this stage the mathematics has been fairly straightforward and explained in such a way that it should present little difficulty to the average reader, even if parts of it are entirely new to him. Afterwards the mathematics become more advanced and the subjects covered constitute the gap in knowledge that it is the author's purpose to fill. The chapter on the theory of functions of a complex variable warns the reader in the introduction that it is almost purely mathematical but essential for the understanding of the subsequent chapter. It deals with analytic functions, contour integration and conformal transformation ; it includes Green's theorem and, in an appendix, Laurent's theorem and Weierstrass's theorem. Concentrated in the next chapter are the very important subjects of Fourier series, the Fourier integral and transform, the Laplace transform and Heaviside's expansion theorem, and four appendices which contain proofs of theorems. If this is a new subject the reader may find this concentration rather indigestible. The treatment is inclined to be terse and the understanding would be improved by more explanation and illustration.

The specialist subjects contained in the last part of the book with a chapter for each are : vector analysis, some special functions and equations, probability and statistics. The vector operators are explained and their use demonstrated by their application to Maxwell's equations. The treatment is again rather condensed. The special functions and equations dealt with in the next chapter include Laplace's and Legendre's equations and Bessel and Gamma functions. This is a well chosen selection of mathematical subjects important in telecommunications. The inclusion of the last chapter on probability and statistics is very much welcomed. After an explanation of permutations and combinations the Binomial distribution and the Poisson distribution are logically derived. The latter is illustrated by an application to an automatic exchange traffic problem. It is surprising that the Gaussian or normal distribution has not been included. The communication engineer concerned with propagation will in addition be confronted with a Raleigh distribution. This is not always given in standard textbooks on statistics but should find a place in one with a telecommunication bias. Some reference might have been made in this final chapter to Information Theory or Communication Theory, subjects which have their basis in probability and which must be of interest, if not of direct concern, to all engineers and students in the field of telecommunication.

The book is very well produced and laid out with chapters divided into numbered sections which are given in the contents at the beginning of the book and in the index at the end, making it very easy both to see the subjects covered and to use the book for reference purposes. At the end of each chapter exercises on each section are given, with answers at the end of the book, and a bibliography for reference and for further reading. For the benefit of the student further exercises, again with answers, are given at the end of the book. In an attempt to write a book to serve two purposes the author by having to compromise might easily have failed in both. However, by a careful choice of subject matter, by the annotation of special sections in the text of the chapters, by the inclusion of the more mathematical proofs in appendices, and by the general guide to the reader throughout the book, the author has succeeded. The value of the book would be enhanced if the subjects covered were extended to include some of the omissions that have been suggested ; the students and the engineer without much previous knowledge of other than elementary mathematics would be better served if the second half of the book were expanded to allow for a more gradual treatment. The book can be considered to serve yet a third purpose, that is as a reference book for the communication engineer who has already covered the ground but wishes to check up a particular mathematical point.

The author has no need to apologise for "another textbook on mathematics." This book *Mathematics for Telecommunication Engineers* will be welcomed by telecommunication engineers. For any or all of the purposes which the book serves it is recommended.

Höhere Technische Mechanik. By ISTVAN SZABO. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz, 3. Price DM.31.50.

"HIGHER TECHNICAL MECHANICS" is the continuation of the author's *Introduction to Technical Mechanics*, both volumes being based on his lectures as professor of mechanics in the University of Berlin. Beginning with the Principle of Virtual Work, and those of D'Alembert and Hamilton and Lagrange's Equations of Motion, the statics and dynamics of rigid and elastic bodies are developed, including a brief treatment of the Calculus of Variations. This is followed by an exposition of the theory of elasticity and applications to thermal stresses ; theory of shells, torsion and buckling, &c.; and of the theory of plasticity and its applications (plastic flow, rolling of metals). The last chapter deals with the mechanics of liquids and gases, including compressible gases. Each chapter is supplemented by a section containing worked examples, and the present second edition contains further examples of interest in an appendix.

Uber das Verhalten von extrem schnelläufigen Axialmaschinen. By PETER G. BUHNING. V.D.I. - Verlag G.m.b.H., Düsseldorf, Ingenieurhaus. Price DM.15.

THE problem of the most efficient diameter-speed combination is investigated for axial flow machines of extremely high specific speeds on the assumption of constant circulation over the length of the blades, for machines with guide blades downstream of the rotor, and for machines without guide blades. The results are expressed in terms of dimensionless diameter and speed coefficients. Agreement with experiment is found to be good.

Books Received

The Physical Metallurgy of Rolling. By F. H. Scott, Arthur H. Stockwell, Ltd., Elms Court, Torrs Park, Ilfracombe, N. Devon. Price 10s. 6d.

The Report of the National Chemical Laboratory, 1958. Department of Scientific and Industrial Research. H.M. Stationery Office. Price 5s. 6d.

Theoretical Elasticity and Plasticity for Engineers. By D. E. R. Godfrey. Thames and Hudson, Ltd., 30, Bloomsbury Street, London, W.C.1. Price 42s.

Adhesives Guide. By J. Hurd. British Scientific Instrument Research Association, "S.I.R.A.," Southill, Elmstead Woods, Chislehurst, Kent. Price 20s.

Méthodes Générales D'Essai et de Contrôle en Laboratoire. Vol I. Mesures Geometriques et Mecaniques. By R. L'Hermite. Editions Eyrolles, 61, Boulevard Saint-Germain, Paris 5e, France. Price Fr.9.700.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GLOSSARY OF TERMS IN WORK STUDY

No. 3138. Price 7s. 6d. This new standard glossary has been seven years in the making—which gives some indication of the difficulties encountered in its preparation. Drafting was in the hands of a specialist committee under the chairmanship of Mr. R. M. Currie, head of the I.C.I. Central Work Study Department, and acting as representative on the committee for the F.B.I. Among the other organisations whose representatives helped to draft the glossary were : British Employers Confederation, Trades Union Congress, European Productivity Agency, Ministry of Labour, Department of Scientific and Industrial Research, British Institute of Management, Work Study Society, and the major engineering institutions.

The new glossary consists of thirty-eight pages. Part 1 begins by defining three general terms : "work study" itself, "method study" and "work measurement." Part 2 defines terms recommended for use in method study. Part 3 contains a large number of terms and definitions relating to work measurement. The glossary covers modern techniques and recommends the adoption of a standard scale of rating and performance uniform for work of all kinds. Throughout the glossary preferred terms are listed in bold type while non-preferred synonyms are printed in lighter type. Each term is numbered for ease of reference, according to its position in the glossary. The standard is fully indexed.

An appendix contains terms used in specialised fields closely associated with work study : job evaluation, merit rating, incentives, labour control, plant and machine control, and wages and wages payment.

LUBRICATING NIPPLES AND ADAPTORS

No. 1486 : Part 1 : 1959. Price 7s. 6d. This publication specifies the overall dimensions and thread sizes of lubricating nipples and limited supply plugs, as well as those for straight and angled adaptors for the $\frac{1}{8}$in UNF. and $\frac{1}{8}$in B.S.P.F. threaded items. In it unified threads to B.S. 1580 have been specified, in addition to British Standard pipe fastening threads to B.S. 2779.

Two types of nipple suitable for normal oils or greases are dealt with. The first type—"button head" nipples (formerly known as "hexagon-headed") are for use with connectors which slide on the nipple head. A change in design which resulted in the removal of the hexagon from the head of these nipples has led to the change in name. The second type concerns hydraulic nipples, both straight and angle types, for use with connectors of the "hydraulic chuck" type. In these, hexagon bodies for straight adaptors and limited supply plugs have superseded cylindrical bodies.

The standard specifies materials for nipples, plug bodies, and adaptors. Also dealt with are case-hardening and electro-plating treatments, as relevant, for the ferrous items. An appendix deals with the use of nipples and with the clearances required for the application of connectors and minimum spacings for grouping.

SOFT SOLDERS

No. 219 : 1959. Price 4s. This publication includes the requirements for the ten grades of soft solder for general use specified in the 1949 edition, together with requirements for four additional solders —"N" and "H," which had been included in an earlier edition of the standard, "V" which is identical with a solder specified in B.S. 441 : "Resin Cored Solder Wire," and "R," a non-antimonial version of solder "M."

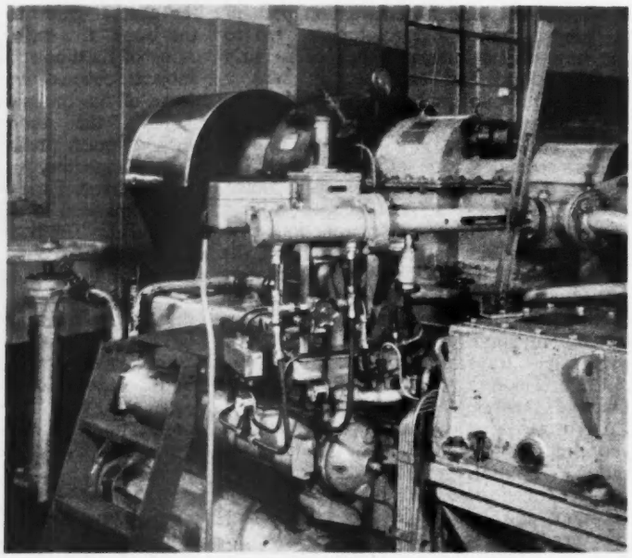
Requirements relating to three solders for service at higher temperatures which were previously referred to in an Appendix, now appear in Section Three of the standard. These solders have been designated by their maximum tin content, followed by a letter indicating the major alloying element, to distinguish them from the solders for general use, which are designated by letters as in the earlier edition.

STEEL BEARING PLATES FOR FLAT BOTTOM RAILWAY RAILS

No. 751 : 1959. Price 4s. First published in 1937, this British Standard has been revised as part of the programme of bringing up to date all British Standards covering permanent way material—a task necessitated by the recent revision of B.S. 11 : "Flat Bottom Railway Rails," and by the changing practice in ordering steel bearing plates. Among the requirements specified are those for : quality of material ; holing, branding, cleaning and dipping the plates ; and establishing freedom from defects. Drawings of sections of bearing plates have been excluded, since the sections vary considerably throughout the railway organisations.

Axial Flow Gas Compressor

An axial flow gas compressor developed and built by W. H. Allen Sons and Co., Ltd., has been installed in the Washwood Heath compressing station of the Birmingham division of the West Midlands Gas Board. This machine, with specified capacity of 600,000 cubic feet per hour and a maximum operating pressure of 25 lb per square inch gauge, delivers gas into the high-pressure mains system serving districts on the south and south-west side of the city. An axial flow compressor, which can be seen on the right, was decided upon in this case because it offered advantages in efficiency, size and capital cost.



WHEN a high-pressure gas main system in the Birmingham division of the West Midlands Gas Board was extended between 1954 and 1957, the plans included the establishment of a new compressing station at Washwood Heath and the increasing of the main operating pressure from 17 lb to 25 lb per square inch gauge, to make possible the doubling of the capacity of the system from 1,250,000 to 2,500,000 cubic feet per hour. Having taken into account the characteristics of the system and the economics of conventional gas compressing plant, it was decided that for the proposed installation an axial flow compressor would offer advantages in efficiency, size and capital cost. The development of such an axial flow machine was entrusted to W. H. Allen Sons and Co., Ltd., of Bedford, it being specified that the compressor should have a maximum operating pressure of 25 lb per square inch gauge, a working range from 7½ lb to 25 lb per square inch, and a volume range from 300,000 to 600,000 cubic feet per hour.

The axial compressor developed and built by the firm, to be seen in our illustrations, is based upon experience acquired in building the gas turbines for marine services which have been described from time to time in these columns. There have also been used in the plant modern automatic control techniques to enable the set to accommodate satisfactorily changes in gas demand.

The compressor is driven by a constant speed 3000V, 3000 r.p.m., 1150 h.p. squirrel cage induction motor through a " Fluidrive " hydraulic coupling and an Allen/Stoeckicht speed increasing epicyclic gear. This arrangement gives a very flexible transmission and high efficiency at full speed, since the motor efficiency is 94 to 96 per cent at a power factor of 0·9–0·91, the fluid coupling efficiency is 98 per cent and the gear efficiency 98 per cent. The set is mounted on a fabricated base plate which also acts as the oil tank. From this tank oil is supplied to the plain bearings (at 30 lb per square inch) and the control gear (at 70 lb per square inch) by a motor-driven gear pump on the same electrical circuit as the driving motor. The hydraulic coupling is supplied by its own centrifugal pump.

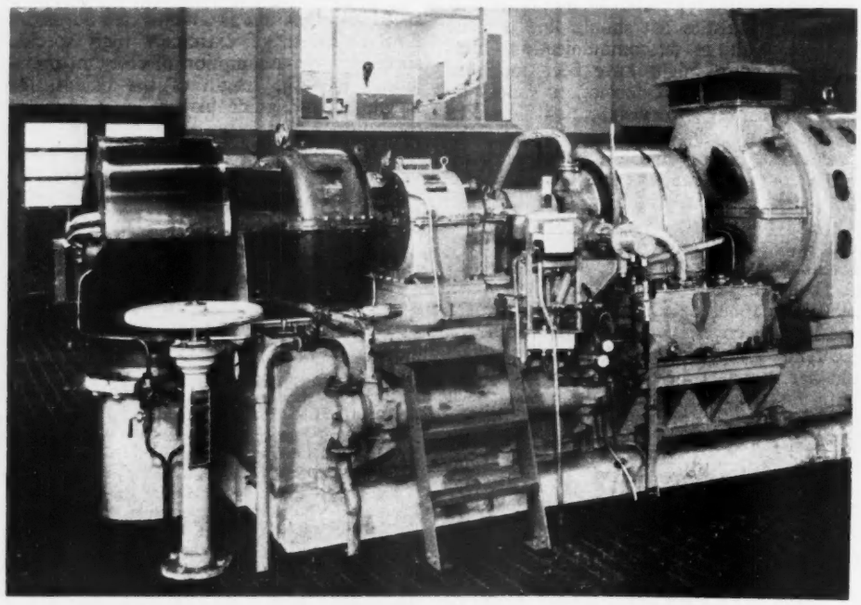
Special attention has been paid to sealing the blading against oil leakage from the compressor bearing glands, as any oil leakage on to the blades would produce an ideal base to which fouling material could become attached. The gland spaces are evacuated by an extractor pump located in the basement of the compressor house.

The blades of the fourteen-stage axial flow compressor are made of aluminium bronze and, as any leakage of gas between the tips of the blades and the casing reduces the operating efficiency, the tip clearance has been reduced to the absolute minimum consistent with safety. In this machine the minimum cold tip clearance is 0·015in, whilst the minimum axial clearance between the rows is 0·035in.

Compressor Tests

In view of the completely new design of the machine, the West Midlands Gas Board co-operated with the makers by making available facilities for exhaustive site testing. This co-operation was particularly welcomed by W. H. Allen Sons and Co., Ltd., as, although the firm had considerable experience in the calibration of axial flow compressors, it wished to make detailed investigation in their performance in a new application. Before the equipment was installed, a series of works tests were carried out at Bedford. A complete calibration, using air, was made to cover the equivalent gas working range and to check that the design was capable of giving the required throughput. The compressor was also momentarily surged at several speeds to check the position and shape of the surge line.

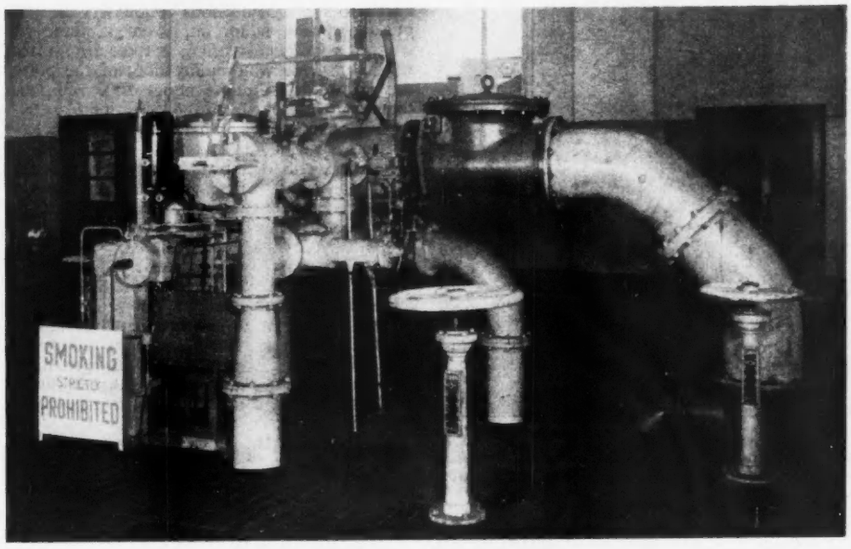
In addition to the calibration, aerodynamic tests were undertaken on the compressor inlet. Any flow irregularities here would be undesirable as they might excite blade flutter, leading to fatigue failure. Certain fairings and streamlining of struts, &c., were suggested by these tests and, as a result, the flow conditions to the inlet guide vanes and first row of rotating blades were considerably improved. Aerodynamic rig tests are a routine procedure in all flow passages of gas turbine machinery and, during these tests, strain gauges were fitted to four stator blades in the first, ninth and fourteenth stages to investigate blade vibration and bending stresses under running conditions. These gauges, of a special type, were designed to follow closely the blade profile, and their leads were taken out through a connection



Axial flow gas compressor set for delivering 600,000 cubic feet of gas per hour at 25 lb per square inch into high-pressure mains

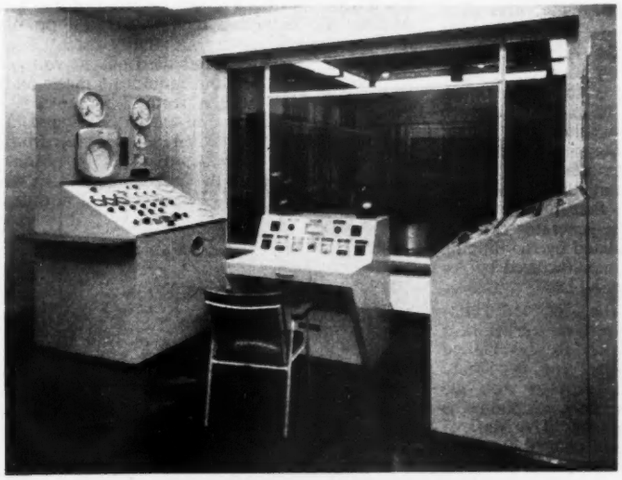
in the casing. In order to interpret the results subsequently obtained from an oscilloscope, it was necessary to obtain a calibration by exciting one blade in a rig by directing a jet of compressed air at the tip.

The compressor calibration was repeated on site under normal running conditions and and 88 per cent over the useful working range of the compressor, a very satisfactory figure.



Flow and surge control equipment for axial flow gas compressor

during this period, as gas could not be passed into the mains, it was recirculated back into the compressor inlet through a by-pass valve. By adjusting this valve the back pressure on the compressor could be increased and the constant speed lines plotted. The compressor was again momentarily surged as at Bedford and the position of the surge line checked. Photographic and visual



Control room of gas compressor plant at Washwood Heath station

observations were made from the strain gauges on an oscilloscope, and it was found that the stresses and frequency of vibration were of a very low order at all conditions, confirming that the machine was aerodynamically satisfactory.

The compressor adiabatic efficiency (total to total) was calculated from the measured temperature rise and the calculated temperature rise based on the measured pressure ratio. This was found to be between 82

Automatic Control Equipment

A requirement for this plant was that it should be capable of adjusting itself to meet the variation in gas demand during normal day-to-day running. Although intended as a base load machine for operation at full capacity and maximum efficiency, there must inevitably be periods when flexibility in operation would be an added advantage even though the plant would not be operating at maximum efficiency. It was decided that two basic controls would be required and the co-operation of Evershed and Vignoles, Ltd., was obtained in this connection.

As the gas demand increases, the pressure in the mains falls and the compressor speed must be increased to keep up the mains pressure. Conversely, if the demand falls, the mains pressure will rise and the compressor speed must be reduced. The control equipment provided for :

Proportional action, a control action varying directly with the deviation from the desired value : integral action, a control action which changes at a rate which varies directly with the deviation : and derivative action, a control action varying directly with the rate at which the deviation changes.

After experiments it was considered that proportional control would be more simple, stable and acceptable for the plant in spite of a small amount of " offset " inherent in all proportional controllers. A proportional band of 30 per cent decided upon is such that the regulating unit will produce a full speed change for a gas pressure change of 30 per cent of the full pressure range (in this case 30 lb per square inch).

The compressor must not be operated in a surged condition, but in some periods of operation—when the required flow is small and the pressure is high or under starting and stopping conditions—surge conditions may be invoked. Under these circumstances more gas than is required must be compressed, and the surplus is by-passed back to the compressor inlet. This procedure is fundamentally inefficient but it increases the scope and flexibility of the plant. The by-pass valve used is controlled independently of the speed control equipment so that it may open and close automatically as the compressor approaches or moves away from surge conditions, and it is held open only a required amount for as long as is necessary.

The control equipment provides for two variables, flow and pressure, to make the plant operate in accordance with the specification. It was decided to include also a surge controller as it is possible for the speed and flow controllers to be in operation at the same time. This is undesirable as the two controllers tend to compete with each other and a condition of instability is produced. The first function of the surge controller is to lock the speed fractionally before the opening of the automatic by-pass valve. Should, however, the automatic by-pass valve fail to open, the compressor operating point may continue to move towards surge, and to meet this condition a further safeguard is provided in the form of an emergency automatic by-pass valve. This valve is arranged in parallel with the main automatic by-pass valve, and on its being opened the entire gas flow is discharged back into the compressor inlet and the supply of gas into the mains will cease by the closing of a non-return valve.

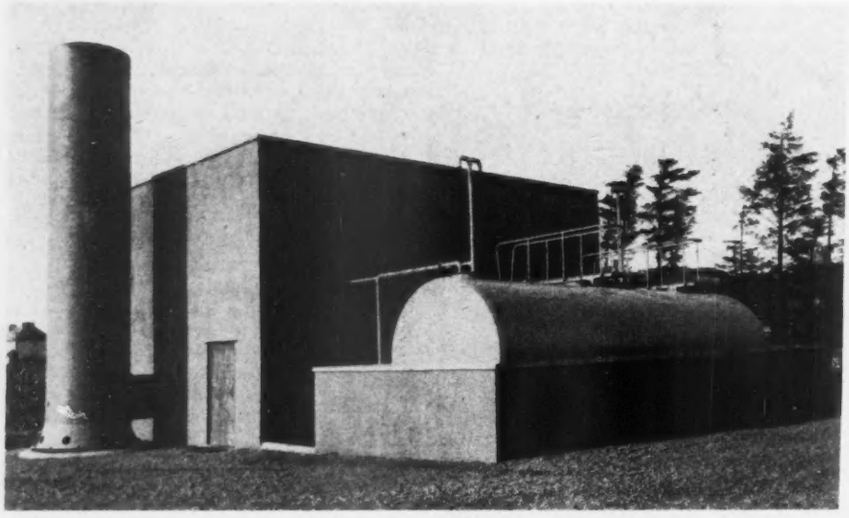
It was appreciated from the start that the gas handled would contaminate the blades of the compressor, and for cleaning purposes four sprays have been built into the compressor casing. These sprays are fed with benzene from a tank by a semi-rotary hand pump in a daily cleaning routine which occupies about three minutes. The progress of blade fouling is observed by deterioration of the machine's performance, and a set of curves has been supplied by the makers to enable an assessment to be made of fouling conditions at the blades.

We are informed that this compressor set is now in daily service and a second similar plant, to be installed in the near future, will be capable of running in parallel with the first.

C.I.B.A. Research Fellowships

THE C.I.B.A. Fellowship Trust, which was founded for furthering the exchange of ideas between scientists in the United Kingdom and on the Continent, announces that several Fellowships will be awarded for tenure in the academic year 1960-61 at Continental universities or institutions for research in chemistry, physics or other allied scientific subjects. They will be awarded to graduates of universities in Great Britain and Northern Ireland or in the Republic of Ireland. Some Fellowships will probably be awarded to recent graduates and other Fellowships to candidates who have already taken their Ph.D., or have worked in industry. The basic award for Fellows who have some training in research and wish to continue post-doctorate studies, will be £800 per annum plus allowances. For candidates who have obtained a first degree in science and desire training in research, the basic award will be £500 per annum plus allowances. Further details are available from the C.I.B.A. Fellowship Trust, C.I.B.A. (A.R.L.), Ltd., Duxford, Cambridge.

Remotely Controlled Power Station



This gas turbine power station is remotely controlled and monitored over the public telephone service. Within, a fire wall behind the gear casing separates the engine proper from the generator and control equipment

LAST Friday the Chairman of the Electricity Council, Mr. C. R. King, C.B.E., formally started up a power station at Princetown, Devon, from the control centre in Bristol of the South Western Electricity Board. The power station is intended for standby and peak-chopping employment, and is normally unmanned : it is visited once a month for routine maintenance.

Gas turbine power plant is expected to appear attractive for applications in which the utilisation is low, and the need for extreme reliability emphasised the appeal of the simple continuous-flow engine. In this instance, a high degree of automaticity was needed to simplify the control problem, and hence an aircraft engine commended itself : such an engine may be unnecessarily expensive by virtue of complying with such requirements as that a disintegrating turbine shall be contained within the engine, but an example can be chosen which is in comparatively large scale production and for which overhaul facilities may be expected to remain in being long hence.

In this instance the engine selected was the Bristol-Siddeley " Proteus " free-turbine engine rated at 4250 s.h.p. The desire to construct and commission the plant without delay led to the choice of an alternator speed of 1000 r.p.m. (900 r.p.m. with an eight-pole 60 cycle alternator) and consequently the aircraft version is employed, rather than the " Marine Proteus " with a high-speed output. The turbo-prop unit normally has an electric throttle control, but in this case a hydraulic servo has been substituted, although commands and signals continue to be electrical. A stabilised source of 50 c/s is provided in the power station as a master when the set is running independently of the overhead supply line. The maximum output corresponds to a constant compressor speed down to 30 deg. Fah. ambient, and below this temperature to constant fuel flow. Although the engine without an airscrew is not particularly noisy, the exhaust stack takes the form of a simple silencer.

The alternator is a 3200kVA, 11kV, three-phase machine ; there being no cooling water in a gas turbine station, it is direct air cooled, and heaters are installed in the windings to prevent condensation when standing. Thin shell bearings are used, the oil being circulated by motor-driven pumps which are started up before the engine ; even at starting the bearings are not pressure fed, so that in the event of a lubricant pump failure the generator can run for an hour on the oil circulated by the dipping rings. The alternator was manufactured by the Electric Construction Company, Ltd.

The remote control is by the Mark II " Datofonic " system, a development of the Mark I monitoring system introduced to the United Kingdom market earlier this year by Sound Diffusion (Auto-Thermatic), Ltd.; as with the earlier system, its use over public telephones is severely limited in Great Britain. The Mark II equipment affords a number of control functions such as starting and stopping the engine. In addition, the control room can inquire for such quantities as megawatts, amperes and volts, which are transmitted and displayed in terms of percentage of design load. Communication is by coded pulses of 1250 c/s, so that the equipment sounds much like an automatic telegraph apparatus when operating. Reliability is clearly even more important for this device than for the generating set, and it is based exclusively on transistors. A single control desk can monitor up to twenty-five outstations ; the Bristol installation is at present set up to correspond with Filton, Cairns Road, and Princetown. Access to the equipment at the outstation can be gained only by the outstation initiating a call to the control centre, and hence the outstation is arranged to perform this action whenever a telephone call is received by the outstation, as well as whenever a change of state occurs at the outstation. In the event of attempts to report a failure proving abortive, the equipment will finally shut down the power station.

The Princetown station is expected to amass its 1000-hour overhaul life in ten years. A second installation is in hand at Lynton, Devon. While it is philosophically possible to run the alternators as synchronous condensers for purposes of power factor improvement, these sets will not allow such running as there are no free-wheels and the windmilling drag of the power turbine would consume about 1000 h.p., and these engines differ from the " Marine Proteus " in not having oil pump drives from the low-pressure turbine. Bristol Siddeley proposes to erect larger sets for similar employment based on the " Olympus " as a gas generator ; in this case no reduction gear is in existence and the high-speed turbine has no attractiveness, so it is anticipated that conventional 3000 r.p.m. turbo-alternators will be built. Outputs of 18MW for each " Olympus " would initially be available, but increases in the rating of the jet engine give a disproportionate increase in shaft power, and 24MW is expected to be reached. For the low utilisations prevailing, the highest rating available is the most economic, any reduction in overhaul life having comparatively little influence on costs.

Particulars of the industrial engine are given below :

Engine :		
Length	...	111·7in (284cm)
Diameter	...	39·5in (100·3cm)
Reduction gear ratio	...	Power turbine to output shaft 11·593 : 1
Output shaft rotation	...	Clockwise looking on coupling at 1000 r.p.m. for 6-pole, 50 cycle alternator or 900 r.p.m. for eight-pole, 60 cycle alternator.
Fuel	...	Diesel fuel to B.S.S. 2869, Class A.
Oil	...	DERD 2479/1.
Oil Consumption	...	1 to 2 pints per hour (0·57 to 1·14 litres per hour).
Weight	...	1¼ tons (1500 kg).
Performance at s.t.p.	...	Power 4250 s.h.p. (4310 cv). Specific fuel consumption 0·575 lb per shaft horsepower per hour (0·257 kg/cv per hour).

Control panel for gas turbine power station : beside the switchboard are the display dial, speaker, outstation selector and telephone dial

Transistor Power Supply

A NEW transistor power supply, Type TF 1303, which occupies less than half a square foot of bench space and weighs under 10 lb, has been introduced by Marconi Instruments, Ltd., St. Albans, for supplying highly stabilised power to low-voltage circuits, particularly those using transistors. The shunt-stabilised output voltage is monitored by a built-in large-scale meter and is continuously variable from 2·5V to 24V. Maximum available output current is dependent on the voltage being delivered and varies from 1·25A at 2·5V to 0·2A at 24V. A power-limiting switch enables the output to be restricted to a maximum of 12W, 2W, or 500mW in order

Supply unit with transistor-controlled shunt regulator and power limit switch for stabilised output to low-voltage circuits

to afford protection against transistor burn-out in the experimental circuit. In addition, the shunt stabilisation allows the output terminals to be short-circuited without damage to the unit.

The output circuit of the unit is completely isolated both from the supply mains and chassis. Either terminal may, therefore, be connected to earth ; or, alternatively, the supply may be arranged to float at a potential not exceeding 100V with respect to earth. This makes it possible to connect two or more units in series, in order to obtain higher voltages.

The d.c. supply is derived from a mains transformer via a full-wave rectifier comprising two germanium-junction diodes, and is fed to the output terminals via a series resistor. A high-power transistor connected across the output forms a shunt regulator under the control of a transistor amplifier. The power transistor continuously samples the output voltage, passing more current when it tends to rise and less when it falls. This determines the proportion of the rectified voltage appearing across the series resistor and hence the voltage appearing at the output terminals. The amplifier controlling the power transistor uses a conventional circuit with four d.c. coupled transistors. The voltage appearing across the output terminals is applied to the base of the first transistor via a potentiometer, which is adjustable from the front panel and forms the output-voltage control.

Load regulation of the unit is stated to be better than 0·01V, and the ripple content less than 0·5mV. It may be operated at ambient temperatures of up to 45 deg. Cent.

Lubrication of Bearings Under Fluctuating Loads

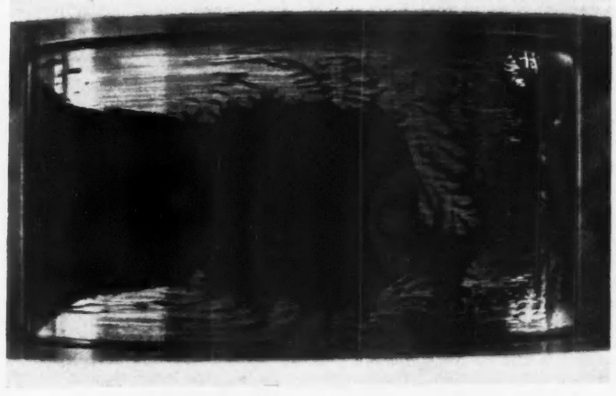
THERE has been disclosed by the Glacier Metal Company, Ltd., Alperton, Wembley, Middlesex, a new technique for lubricating bearings subject to shock loading, as in reciprocating engines. In an attempt to explain inconsistencies in the performance of bearings on different fatigue test rigs, the firm built what it calls a bearing oil film analyser, a machine which rotates a shaft within a transparent bearing housing ; the housing is loaded radially by two hydraulic rams at right angles, the loading programme being determined by a series of cams driven from the main shaft. With this machine the loading conditions of an actual engine bearing can be simulated, similarity of Sommerfeld number being obtained with much reduced speeds and pressures but increased viscosities ; the bearing runs so slowly that the behaviour of the film can be observed without resort to stroboscopic techniques. The shaft speed is 7 r.p.m., say one-seventieth full scale, the pressures are one-fourteenth full-scale and the viscosity 5× full scale.

With this machine it is readily shown that when a high radial load is applied to the bearing, the oil film on the unloaded side of the bearing becomes discontinuous, forming voids or cavities. These cavities are then carried round at about half the running speed ; thus in a two-stroke engine it can be imagined that the cavities formed as the peak loads are applied on one cycle would, 360 deg. later, have been transferred to that section of the bearing where the load is about to be applied. This is clearly highly prejudicial to the bearing, since only a partial oil film will be present to accept the load, and the inner and outer parts of the bearing will come together with a relative velocity that will involve severe impact loads.

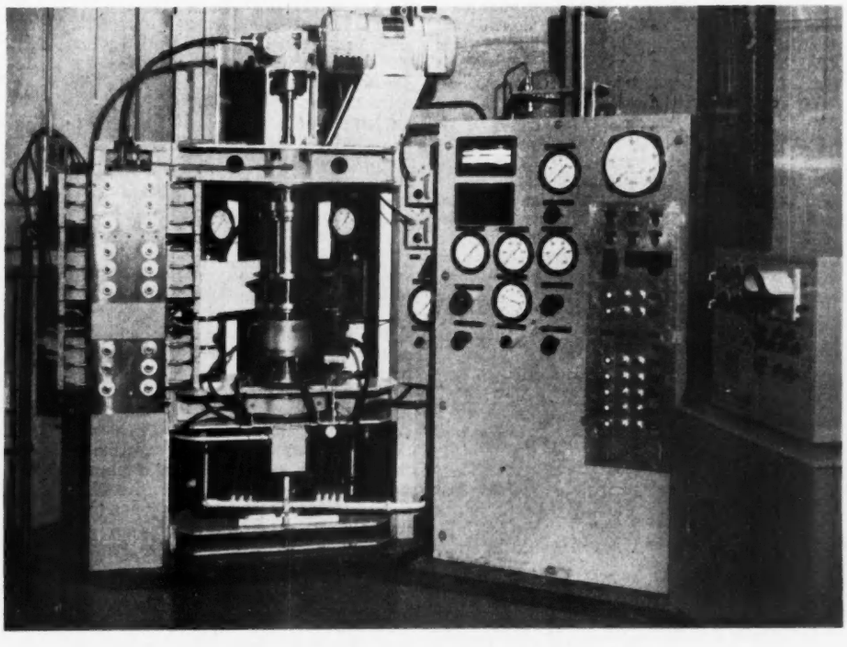
The proposed technique to avoid this adverse behaviour, named "Ramrod," is to force a specified volume of lubricant into the bearing at the sector to be loaded before the load is applied. Thus any cavities in the oil film are filled, and there are the advantages that the extreme load falls on a thick film of cool oil. The injection is expected to occupy about 60 deg. of crank angle and to be provided by a separate positive displacement pump for each bearing ; this multiplicity of pumps in an actual engine is justified by the fact that the phasing of injection on different bearings will probably overlap, and the supply of a metered volume of oil is fundamentally more attractive than connecting the bearing to a pressure source, in which case the delivery depends upon the temperature, the running clearance, and so on.

The first applications of "Ramrod" are expected to be to large engines, on which speed is sufficiently closely controlled for stresses not to be forced down by fatigue and for which the cost of the engine is very largely that of the metal and the machining rather than auxiliaries and inspection, so that reductions in the size and weight of the engine effect large changes in the cost. The duty of the oil pumps is not particularly critical, pressures of perhaps 900 lb per cubic inch being involved, and installation merely means providing a groove in a main bearing housing phased to meet the drilling leading to the big end ; it might prove necessary to have two supplies to each big end. The main bearings, clearly, present no difficulty at all. It is estimated that a 1000 h.p. engine would require 1 cubic inch of oil to each bearing per cycle, to provide which would consume 2 h.p. It is anticipated that the system would allow the up-rating of many existing engines which are limited by the life of the bearings supporting, say, the centre journal of a symmetrical crankshaft.

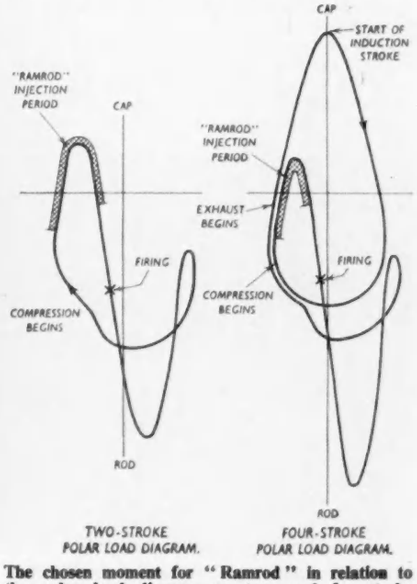
The Glacier Metal Company is at present running an engine with half the bearings equipped with "Ramrod," and a programme of experiment at full scale is being undertaken in the Shell Research Laboratories.



Cavities in the oil film being swept around inside the transparent housing



The Glacier bearing oil film analyser. Below the transparent bearing is the rotary union supplying the oil, and on the right of it the "Ramrod" pump. In the left-hand panel are the cams generating the desired polar loading diagram



The chosen moment for "Ramrod" in relation to the polar load diagram on two- and four-stroke engines

SHORTER REPORTS

Association of Short-Circuit Testing Authorities

THE Association of Short-Circuit Testing Authorities (A.S.T.A.) was formed in Great Britain in 1938 primarily to meet the need for a responsible body that would co-ordinate circuit-breaker tests and test methods at the separately-owned testing stations and would issue certificates of rating that would be nationally recognised.

Before 1938 the proving of switchgear by short-circuit testing was the individual responsibility of a handful of manufacturers who had on their own initiative and at their own expense set up testing stations because there were no other means of assessing the performance of switchgear in service. Previously, circuit-breaker ratings were determined by empirical methods based on experience in service and on the fundamental research done by manufacturers and by the Electrical Research Association. Such tests as could be made in the works (when an alternator manufacturer happened to have available a machine of sufficient capacity) or in the field (on the occasions when interruption to the supply could be tolerated) were rare. The results of such tests added little to the knowledge of the subject of switchgear behaviour as a whole. With the growth of interconnected networks linking large concentrated sources of power, it became increasingly difficult to provide circuit breakers capable of dealing with the large short-circuit faults that could occur.

In the mid-1920s the idea of setting up an independent organisation to operate a short-circuit testing station and to carry out certification tests on a national basis was sponsored by a number of engineers including the late Mr. H. W. Clothier and the late Mr. E. B. Wedmore. However, the attempt failed and individual manufacturers had no alternative but to make testing arrangements for their individual needs. The first firm to build a short-circuit testing station was A. Reyrolle and Co., Ltd., at Hebburn on Tyne. This station was commissioned in 1929 and it enabled the company to carry out the development testing and rating of 132kV, 1500MVA circuit breakers for the British grid system. Within the next nine years three more testing stations were built by other manufacturers. Although the four stations operated independently there was considerable exchange of ideas and experiences in the new and unfamiliar testing techniques. These exchanges immediately helped the development of switchgear and laid the foundation, later, for the establishment of the Association.

In the meantime the very existence of these independent testing stations made it increasingly urgent to set up standards for carrying out tests and assigning ratings to switchgear. There were indeed certain standards in B.S. 116 for the construction, performance and rating of circuit breakers for normal service. But B.S. 116 did not relate to testing performance and ratings under short-circuit conditions. On the basis of experience gained at the British short-circuit testing stations a draft specification was produced and submitted to the International Electrotechnical Commission. The principles embodied in this draft were accepted as the basis for the I.E.C. Specification No. 56, published in 1937. At the same time the recommendations were adopted by Great Britain and two new editions of B.S. 116 were published : one for circuit breakers up to 500MVA and the other for circuit breakers above 500MVA.

Despite this advance, there was still no way of making equitable comparisons between short-circuit tests and the performance of circuit breakers at different testing stations. The immediate need was for the establishment of an independent and responsible authority, to secure uniformity in interpretation of the existing standards, to co-ordinate tests and testing methods at the individual testing stations and to issue nationally acceptable certificates of rating and reports on performance.

It was primarily to meet these needs that the Association of Short-Circuit Testing Authorities was formed in 1938. Its initial membership of seven manufacturing companies operating four short-circuit testing stations has since been expanded to include eleven companies operating eight such stations. One of these stations is designed for the testing of fuses only, but the other seven are fully-equipped for the testing of large circuit breakers, reactors, transformers and fuses.

As an organisation for the testing and certification of electrical equipment it is unique, depending as it does upon the voluntary collaboration of its members who operate some of the largest short-circuit testing stations in existence.

The Association is controlled by a council and a management committee, and a technical committee which is concerned with standardisation and with technical aspects of testing. Liaison with the Department of Scientific and Industrial Research is maintained through the National Physical Laboratory which is represented on the A.S.T.A. technical committee. In addition, the N.P.L. undertakes to approve an A.S.T.A. observer at each testing station to witness the performance of all certification tests and to ensure that the test conditions comply with the appropriate British or foreign standards and with the A.S.T.A. rules. Under this system of routine supervision by the N.P.L., for many years, A.S.T.A. has come to be recognised as the authoritative body for the short-circuit testing and certification of electrical equipment.

For some years short-circuit testing facilities at A.S.T.A. stations have been available to British switchgear manufacturers who are not members of the Association and are without testing stations of their own. Initially these facilities were limited to 11kV and 250MVA. However, as planned extensions to testing stations came into service, these limits were relaxed and from May, 1956, onwards, A.S.T.A. has been able to offer non-member firms testing and certification up to 33kV and 750MVA. The work of A.S.T.A. members has contributed substantially to switchgear development. For example, there has been considerable research over the past ten years into methods of measuring, assessing and specifying the rate of rise of restriking voltage—which is one of the main factors that determine the severity of tests on circuit breakers. The methods developed have been incorporated in appropriate standards by the British Standards Institution and by the International Electrotechnical Commission. In addition, rules have been established for the "synthetic" testing of large circuit breakers whereby their performance under short-circuit conditions can be predicted without subjecting the complete circuit breaker to these conditions.

Proving tests are carried out in accordance with recognised standards. Proving tests can also be done to certify that the rating assigned to any equipment is justified by its performance under standard conditions specified by A.S.T.A. An A.S.T.A. certificate of rating applies only to a specific equipment and each separate rating requires its own A.S.T.A. certificate ; any modification to the design invalidates the certification. Tests for non-member firms are treated as confidential.

The A.S.T.A. testing stations are as follows : Switchgear Testing Company, Ltd. (owned by The British Thomson-Houston Company, Ltd., Metropolitan-Vickers Electrical Company, Ltd., and Ferguson Pailin, Ltd.), Manchester, 17; Crompton Parkinson, Ltd., Chelmsford, Essex ; George Ellison, Ltd., Perry Barr, Birmingham, 22B ; The English Electric Company, Ltd., Stafford ; The General Electric Company, Ltd., Witton, Birmingham, 6 ; W. T. Henley's Telegraph Works Company, Ltd., Gravesend, Kent ; A. Reyrolle and Co., Ltd., and The British Short-Circuit Testing Station, Ltd., Hebburn, Co. Durham.

The headquarters of the Association of Short-Circuit Testing Authorities is at 36, Kingsway, London, W.C.2.

Road Research, 1958

FIVE lines of research are being given special emphasis at the Road Research Laboratory, D.S.I.R., as the result of recommendations by the Road Research Board. This information is given in the report "Road Research, 1958," which has just been published by H.M. Stationery Office. The five research topics are : the relation between the benefits from road improvements and their cost ; traffic capacity ; crash-injury research ; study of means of avoiding slipperiness in road surfaces ; and the problems of pavement design. The Board draws attention to the fact that results of road research take time to achieve ; a period of major activity on a subject is followed by a period of observation and the collection of statistics, a process that cannot usually be hurried.

The Board also draws attention to the shortage of traffic engineers qualified to assist in planning the road programme. It commends the expansion of post-graduate schools in highway engineering at universities and recommends that these and other activities should be extended.

Among the items of research in the report of the Director of Road Research is a section on skidding and safety. The percentage of skidding in accidents decreases with increasing age of the driver. The skidding rate is lower for women than men drivers, except for women under thirty on wet roads. Newer cars are more liable to skid. There is a trend towards higher skidding rates with greater engine capacity, with one exception—motor scooters, which show almost the highest skidding rate for all vehicles in spite of their low engine capacity. Treatment of the road surface at skidding-accident sites by resurfacing and surface dressing has shown a marked reduction in accidents.

A study of the properties of rubbers showing high hysteresis energy losses when deformed has suggested the possibility of producing tyres with better skid-resisting properties on wet road surfaces. After the Laboratory had investigated the possibility of using an aircraft anti-skidding device on road vehicles, a system, by which the wheels of cars are prevented from locking when braking, is being developed by the Dunlop Rubber Company.

The increasing rate of trunk- and motor-road construction has stressed the importance of reinforcing the experience of the highway engineer with scientifically based methods of equating the soil foundation and the traffic to be carried with the thickness of the road structure. The full-scale road experiments being carried out by the Laboratory are being supplemented by the measurement of traffic stresses communicated through the road to the soil foundations.

As a guide to the engineer to help him in the selection of plant for compacting road foundations and embankments, without the fear of further settlement after the construction of the road, the Laboratory has issued a technical paper (No. 45) describing investigations with pneumatic-tyred rollers ; it supplements technical

paper Nos. 17 and 33 which deal with other kinds of machines for compacting soils.

The depth of surface soil unsuitable for stabilisation depends principally on the major soil group to which the profile belongs : since a major soil group can often be identified by visual examination, a large amount of preliminary soil testing can be avoided in locating soil suitable for stabilisation.

Rural Road Standards

BY A CONTRIBUTOR

THE Traffic Engineering Study Group of the Institution of Civil Engineers turned out in strength for the second of its meetings, on December 10, when the paper discussed was on the " Standards of Design of Rural Roads," by J. T. Duff, M.Sc., A.M.I.C.E., A.M.I.E.E., Senior Engineer of the Ministry of Transport's Traffic Engineering Branch. The chairman was Sir Herbert Manzoni.

Mr. Duff gave a reasoned exposition of the Ministry's standards and defended them throughout some two hours of keen debate. The proceedings were informal, meaning that no full record of them will be available, which is perhaps a pity ; for the views and experience that emerged, from among a countrywide attendance, would be of general interest, and of particular value to students of the subject. Space permits mention of only the following few of the very many points that arose, and it is perhaps advisable to mention again that this was only a discussion, and therefore inconclusive.

Traffic Growth.—Does this " nightmare " really amount to only 5 per cent a year ? Higher estimates have been given, and the number of motor vehicles in Britain is certainly increasing more rapidly. The explanation is that traffic is counted in " passenger car units " ; the larger commercial vehicles each count as three passenger car units, and they are multiplying less rapidly than the single units.

Passenger Car Unit.—The rating of 30-cwt vehicles and upwards at three, compared with smaller vehicles one, with no intermediate ratings, perhaps renders the passenger car units fictitious. Use of the American " Truck Factor " might give a truer picture of the actual traffic flows. On the other hand certain very large vehicles might deserve a rating of six passenger car units ; the rating of three passenger car units for 30-cwt vehicles and upwards is a compromise.

Annual Traffic Survey.—Is one survey a year, in the month of August, of sufficient value ? No, says a coastal, holiday county, backed up by a typical South Midlands industrial area. The Ministry should not set too much store by their annual survey—and there is nothing to show that they do. More data are required, but they are expensive ; though not too expensive, apparently, for at least one county has evolved its own punched card system for recording origin and destination surveys.

Lane Widths.—The standard lane width has been increased in recent years from 10ft to 11ft, and then to 12ft. Is this lavish ? The Mersey Tunnel shows that 9ft lanes can carry 1350 passenger car units per full hour (2000 per lane per hour for short periods). One slight economy is the 33ft width of the standard three-lane road ; the central lane, being for overtaking, is presumed to be used mainly by cars : but this economy is not extended to dual three-lane carriageways, which are the full 36ft.

M.1.—To a highway engineer from a southern County it is galling to drive along M.1 and reflect that some £1,500,000 could have been saved—for use elsewhere—had the Ministry been content with two-lane carriageways, with which M.1 would still have been far and away the best road in the country, not loaded to more than a fraction of its capacity. To another from a south-western County, with a year's major improvements grant of £50,000, it seems the same, or more so.

Design Capacities.—Present standard design capacities (per sixteen hour day) are : dual two-lane, 25,000 passenger car units ; three-lane, 11,000 passenger car units ; two-lane, 6000 (recently increased from 4500). Are they very meaningful ? The fluctuations in volume and in tidal direction tend to vitiate them : at peak hours on dual carriageways one carriageway may be carrying four or more times as much traffic as the other. Perhaps the saving grace is that design capacities are commonly recognised to be highly theoretical : one Saturday last summer a single-carriageway 22ft road passed 20,259 vehicles (22,000-odd passenger car units) !

Edge of Carriageway.—This is " the most important part of the road." Has the flush kerb come to stay ? There is a Warwickshire report on the use of both types of kerb on the Meriden by-pass, which avers that " the raised kerb is far superior to the flush kerb " ; drivers prefer it and keep closer to it (21in compared with 27in from the flush kerb). On the other hand there is now the hard shoulder, which may even the score.

Visibility Distances.—The Ministry allows for a reaction time of 2 seconds, some 3 per cent of the population being that slow. Is it extravagant ? Possibly " no one with a two second reaction time can cross a street, let alone drive a car " ! Again, for braking the Ministry adopts a deceleration of only $0{\cdot}3g$. When we are making do at present with roads that have 2·6 bends and 0·3 double bends per mile, and are curved to a radius of less than 500ft for 8 per cent of their length, are we not aiming high in specifying radii in the 900ft–2800ft bracket ? Is it to be quality almost alone, or quality blended with quantity, in new road construction and major improvements ? Seemingly the local traffic engineer will demand a say—or *the* say—in such matters.

Trevelyan Scholarships

THE Trevelyan Scholarships Trust has announced its second list of awards, numbering twenty-three scholarships. It may be recalled that the trust was formed after discussions between a group of industrialists, members of the teaching staffs of Oxford and Cambridge and representative headmasters. It was agreed that, for various reasons, many boys who hoped to go to a University were subject at an early age to heavy pressure to specialise in a narrow field to the detriment of their general development and education. Accordingly, the Trevelyan Scholarships Trust was set up to provide, for a period of years, a number of awards to be tenable at Oxford and Cambridge Universities and to be awarded to boys who were judged to possess exceptional personal qualities as well as the necessary intellectual ability. The scheme was sponsored by a number of industrial companies. Sufficient funds have now been subscribed to permit the award each year of not less than thirty-four three-year scholarships of £450 a year over a period of five years. Selection is made by interview, supported by comprehensive reports from candidates' headmasters, and particularly by the evidence of written reports submitted by the candidates on an arduous and exacting task or project which they have undertaken.

It was arranged, at the outset, that all applications would first be considered at either Oxford or Cambridge, according to the applicants' first choice, by a panel drawn from college tutors and other senior members of the University, and that their projects would be assessed by experts in the particular field covered by each project. In addition, each applicant is given a preliminary interview by representatives of the donor companies. Thereafter the University panels agree upon " short lists " of candidates for final interview by a selection committee. For the second selection 198 applications were accepted, and from these a short list of fifty-eight applicants were interviewed. In 1958, 123 applications were accepted and fifty-four applicants were short-listed. The selection committee endeavoured to maintain an extremely rigorous standard and restricted the awards to twenty-three in number, of which twelve are tenable at Oxford and eleven at Cambridge. In 1958, nineteen awards were made, namely, ten at Oxford and nine at Cambridge. The committee says that it was much impressed with both the intellectual standard and the personal qualities of the majority of the candidates. Many of the project reports were of very considerable merit, disclosing a high degree of originality and an impressive level of attainment in fields which in many cases were quite divorced from the candidates' principal subjects of study at school. The awards are subject to the recipients obtaining a place at Oxford or Cambridge, but the majority have already succeeded in doing so.

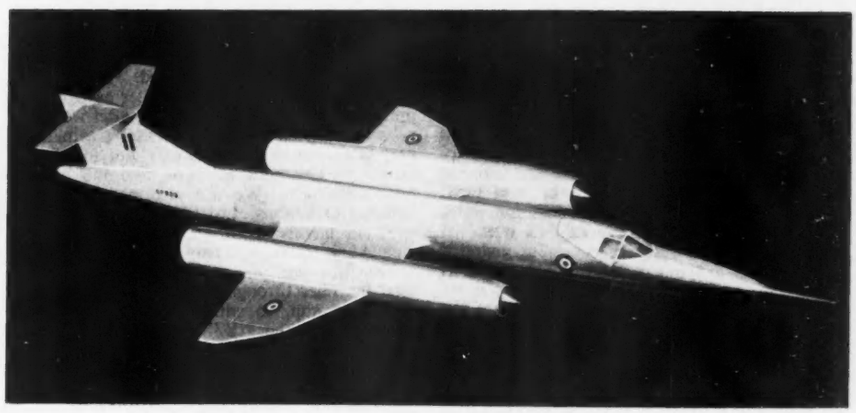
Supersonic Research Aircraft

AN illustration based upon a photograph of a model of the Bristol Type 188 is now available. This machine has been designed largely to investigate the problems of structures and systems in the high temperature environment. It is clear from the illustration that structural problems will be of extreme severity.

The aircraft has two D.H. " Gyron Junior " DGJ-10 engines with afterburners : these engines are claimed to have variable geometry convergent-divergent nozzles, but all that could be seen when an example was displayed at the S.B.A.C. Exhibition was that the complete engine was very, very long, so that there is no doubt that the turbo-compressor assembly is at the front of the nacelles. It will be recalled that the " Gyron Junior " poses the same problem of passing a hot tail pipe through the highly stressed structure in the Blackburn N.A.39 : a possible explanation why the contemporary practice of mounting engines aft is never applied to these units may be that they are outstandingly sensitive to the flow distribution at the intake.

The fuselage is 71ft long, 3ft 9in wide, and 4ft 11½in deep : it contains the fuel and the conventional tricycle undercarriage. The cross-section of the fuselage diminishes slightly in way of the wing to reduce the wave drag. A large area of transparency is provided for the pilot, doubtless by substituting fused silica for glass.

The wing has a span of 35ft 1in and an area of 396 square feet : the thickness is 4 per cent and the section is " modified biconvex." The compound sweep outboard of the engines is at 38 deg. and 64 per cent : thus, the leading edge



An impression of a model of the Bristol 188 single-seater

of the aileron horn balance would be subsonic up to Mach 2·25. Inboard of the nacelles there are plain flaps of large chord. The wing is claimed, despite its contrast with the favoured crescent planforms, to have "good transonic characteristics."

The fin leading edge is swept at 65 deg. Problems of mechanical interference between tail plane and rudder are avoided by mounting the horizontal surface forward of the hinge line. Similar tails have been seen on almost all recent English designs, with the exception of the Avro submission to B.E.A. which, logically for a three-engined machine, had a butterfly tail. It may be inferred that no designer can summon the research and development necessary to make the change to a canard ; in this case it is particularly stressed that the low-speed handling qualities are not markedly different from those of some present-day machines, although it is, of course, true that the same could be said of the performance potentiality.

Elevated Motorway Design Competition

THE Prestressed Concrete Development Group has announced the results of its design competition for an elevated motorway in prestressed concrete. Twenty-five entries were received and considered by the Assessors, who state that there was no outstanding submission which, while being æsthetically good, was also adequate in structural design, in arrangements for traffic flow and in ease of construction. The safety of pedestrians using the lower road was generally ignored and little thought was given to the problem of expansion joints in the wearing surface. All the designs contained defects in one or more of these aspects, the Assessors considered. In some cases, however, the defects could be remedied or reduced without fundamental alteration to the main design.

The first prize of £500 was awarded to Messrs. Crozier, Bennett and Kerry of G.K.N. Reinforcements, Ltd. This design was described as clean, æsthetically acceptable, structurally good and providing a reasonable traffic solution for a design speed of 50 m.p.h. The design envisages a succession of central columns, and the roadway cantilevered from a spine beam stressed after the *in situ* section of the deck has been poured. The composite effect was not considered in the calculations, which assume that the whole of the prestress goes into the spine beams. Otherwise the calculations are thorough, it is stated, and give a satisfactory analysis of torsional and point load problems. The parking section of the motorway is designed in reinforced concrete on an ultimate load basis.

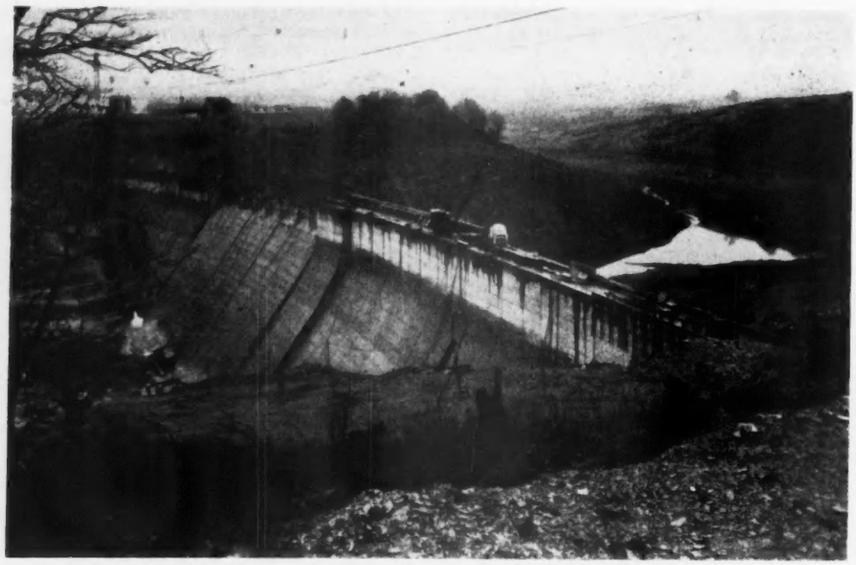
A second prize of £200 was awarded to Messrs. Measor and Bailey (respectively of Scott and Wilson, Kirkpatrick and Partners, and Ansell and Bailey). Three £100 awards were made, to Mr. F. Graham (of Brandt and O'Dell), Mr. R. W. Hobbs (of Ove Arup and Partners), and to Dr.-Ing. Finsterwalder and Dipl.-Ing. Paulus.

The assessors were Mr. H. C. Adams, Ministry of Transport ; Mr. C. P. Andren, Traffic Engineer, University College, London ; Mr. A. G. Jury, City Architect, Glasgow ; Lt.-Col. G. W. Kirkland, Past President, Prestressed Concrete Development Group ; and Sir Herbert Manzoni, City Engineer, Birmingham.

Clatworthy Dam

THE accompanying illustration shows a gravity dam on the River Tone, brought into use last week, by the Taunton Corporation and three adjoining rural districts in Somerset for water supply. The average yearly rainfall over the catchment area of 4500 acres is 46in giving a gross yield of 5·5 m.g.d., of which 1 m.g.d. is compensation water

The original design was for an earth dam but it was suggested by the contractor that a concrete dam might be constructed at a cost not exceeding that of an earthern one. Though this hope was not entirely realised there were certain advantages in a concrete dam; particularly as it was known that it would almost certainly have to be raised, this contingency being brought into the immediate future by the proposal for the nuclear power station at Hinkley Point, the suggestion was adopted and the dam redesigned by the consulting engineers accordingly.



Clatworthy dam just prior to completion

The foundations of the dam are on a form of shale known locally as shillet ; and the dam is of interest because of the use of fly ash in the concrete mixes. The facing concrete of the dam both upstream and downstream is of 1½in maximum size aggregate with an aggregate/cement ratio of 7·5 : 1. The hearting concrete is of 3in maximum size aggregate with an aggregate/cement-fly ash ratio of 10 : 1. In both these mixes the proportion of cement and fly ash is 70 per cent : 30 per cent. A drainage system has been provided under the dam by laying precast concrete "U"-shaped units to drain downstream into the pitched channel. Air was entrained in the concrete to a maximum of 4 per cent by the use of an additive in the mix to improve the workability. Compaction was effected with 6in and 4in diameter poker vibrators. Seven-day and twenty-eight day specific strengths from works test cubes were 1400 lb per square inch and 2250 lb per square inch for the hearting concrete, and 1600 lb per square inch and 2750 lb per square inch for the facing concrete. The total quantity of concrete in the dam is about 87,000 cubic yards. The height of the dam above stream bed is 104ft 6in, and the cut-off trench extends 20ft deeper. The capacity of the reservoir is 1100 m.g. at top water level of 740·5 a.o.d.

The consulting engineers were Messrs. Rofe and Raffety, and the main contractor was Holland & Hannen and Cubitts (G.B.), Ltd.

Spraying Heavy Filler Materials

IN spray-finishing difficulty is often experienced in feeding to the spray gun a material which is heavily pigmented, and which readily settles out when not being used. This trouble usually occurs when spraying filler as part of a finishing process. In such cases, after work has been interrupted for a few minutes the material may settle out in the hose, and spraying cannot be resumed without waste of time and filler in hose clearance. We are informed by Alfred Bullows and Sons, Ltd., Walsall, Staffs, this problem has been solved in production in a simple and inexpensive way.

The firm uses one of its "Pogo" pumps to feed the filler through a standard fluid hose to the spray gun, to which is attached a "Y" piece. From the "Y" piece a second length of hose provides a return flow to the pump and hence to the filler container, in which the material is kept agitated by this constant flow and return. With this simple arrangement, which has now been operating in the firm's works for just over eighteen months, it is possible to pick up the gun and spray filler at any time, without any line stoppage.

The pump can be arranged to pump from a mixing or storage tank, or to be mounted on an existing pressure feed container if preferred. The equipment operates off the existing air line, using less than 3 cubic feet per minute of air at pressures as low as 30 lb per square inch.

[Reply Card No. E8303]

Enlarged Activities of Radio Research Station

THE Radio Research Station of the Department of Scientific and Industrial Research has earned for itself an international reputation for its detailed studies of the propagation of radio waves by way of the ionosphere and the troposphere. Recently the programme has been reviewed and its scope has been extended so as to take advantage of the new techniques provided by rockets and artificial earth satellites. Under its new terms of reference the station will undertake investigations of the upper atmosphere and outer space by both radio and non-radio methods. Half the total staff effort of the station (amounting to about eighty scientists and assistants) will be made available for this purpose. The necessary additional staff is being recruited.

The work of the station has already been enlarged to include the use of radio and optical methods for tracking satellites, and steps have been taken for the provision of a radio telescope. It is the intention to extend the space research further and it is announced that Mr. J. A. Ratcliffe, C.B.E., F.R.S., who will be appointed Director of the station from October 1, 1960, on the retirement of the present Director, Dr. R. L. Smith-Rose, C.B.E., will assist in planning the future research programme at Dr. Smith-Rose's invitation, pending taking up his appointment.

Physical Society Exhibition

THE 1960 Exhibition of the Physical Society will be held at the Old and New Halls of the Royal Horticultural Society, Westminster, S.W.1, from January 18 to 22, opening at 10 a.m. each day (2.0 p.m. on the Monday). Discourses (demonstration-lectures) are to take place as follows, each commencing at 5.45 p.m.

Monday, January 18 : "Some Reactions of the Human Body to the Stresses of High Performance Flight," by Flight-Lieutenant J. Billingham (R.A.F. Institute of Aviation Medicine).

Tuesday, January 19 : "Atomic Time," by Dr. L. Essen (National Physical Laboratory).

Wednesday, January 20 : "Recent Advances in Solid State Physics," by Dr. D. A. Wright (Research Laboratories of the General Electric Company, Ltd.).

Automatic Dish Washing Machine

THE technique of carrying out a sequence of operations by automatic control, long familiar in engineering, is being increasingly applied to domestic equipment, and an excellent example of such an application is in the recently introduced dishwasher of Charles Colston, Ltd., 7–11, Lexington Street, London, W.1. In this piece of labour-saving equipment, seen in the illustration below, clean modern lines have been

Crockery being removed from chamber of automatic dish washing machine

combined with engineering techniques to provide an efficient, automatic and lightweight unit. As engineers, and indeed as occasional and somewhat reluctant "sink operatives," we found this new piece of equipment of particular interest at a recent demonstration in London. The dirty crockery is loaded into the racks of the washing chamber, as shown, and when the door has been shut the sequence of washing, rinsing twice and drying is completed and the power switched off without further attention. The unit can be placed on any normal draining board by a sink and only needs to be connected to a water tap and a power supply.

Cleansing of the crockery is effected by hot water being continuously recirculated by a pump and thrown by the jets of a centrally disposed accelerator to all parts of the chamber and its contents. A recess in the floor of the chamber forms a sump for the pump and is covered with a coarse mesh filter which serves to prevent any large solids being drawn into the pump during recirculation of the water in the washing cycle. A second fine-mesh filter is fitted on the rotating accelerator to remove smaller solids which might clog the jets.

The operating equipment and control gear are totally enclosed in a compartment below the washing chamber. The drive is provided by a fractional horsepower motor and the water is heated by a 2½kW element situated in the sump. The motor, which runs constantly, drives the pump and the jet accelerator through vee belts, and the drive is extended through epicyclic reduction and two-speed gearing to rotate a camshaft by which the operational sequence is controlled.

When the dirty crockery has been loaded into the chamber with a quantity of detergent the working cycle is started by depression of a switch. A valve then opens to admit precisely 1 gallon of water into the chamber and the water is circulated through the accelerator by the pump. The element in the sump heats the water as it is circulated and until a temperature of about 140 deg. Fah. is attained the camshaft is being rotated at its lowest speed through the two-speed gearing. At the water temperature of 140 deg. Fah. a thermostat control switches the camshaft drive to its higher speed to hasten the subsequent water replacement sequence.

In this sequence a cam, through a cable connection, swings over a flap in the pump line and the dirty water is diverted from the accelerator delivery to a drain tube leading into the sink.

The water inlet valve is then opened to deliver another gallon of water into the chamber for rinsing purposes and the lower temperature of this water operates the thermostat to engage the camshaft low-speed drive until the fresh water has been heated to 140 deg. Fah. for the previous cycle to be repeated. This rinsing operation is carried out a second time and during it a dose of "Rinshine" compound is delivered into the chamber through an injector. It will be appreciated that the thermostat-control ensures that the water in each case attains a preset temperature for effective cleansing, irrespective of that at which the water is delivered into the chamber.

For the drying cycle, air, heated in its passage through the driving motor, is blown into the chamber by the motor fan and vented through louvres at the top of the cabinet. At the end of a predetermined drying period the power supply to the machine is switched off.

The washing chamber door is interlocked with the main power switch so that should it be opened during a washing cycle the current supply is automatically switched off. When the door is lowered the crockery, nested in sliding plastic-covered wire shelves, can be easily withdrawn.

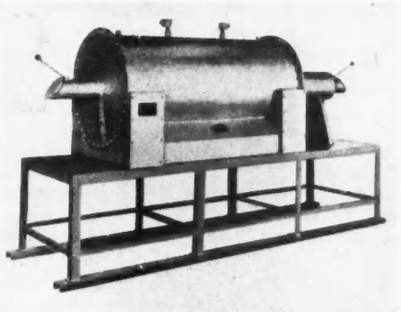
[Reply Card No. E8311]

High-Temperature Sintering Furnace

A HEAVY duty sintering furnace for operation at temperatures up to 1650 deg. Cent. with a hydrogen atmosphere has been manufactured by Royce Electric Furnaces, Ltd., for a special application. Its heating chamber comprises a replaceable tube of fused alumina 5in inside diameter with a a heated length of 32in. Fused alumina tiles which house heavy section molybdenum heating elements surround the tube along the heated length and also serve to support the tube, allowing free dissipation of heat and providing mechanical strength. A high temperature insulation of porous alumina behind the bricks is backed by graded thermal insulation to reduce heat losses to a minimum.

With this design a mechanical failure of the work tube, due to thermal shock, or stress from the charge load does not cause failure of the heating elements. Conversely, the work tube is unaffected by an electrical failure of the elements, which can be replaced individually in the segmental alumina tiles. A considerable sensible heat is absorbed in the refractory lining which acts as a heat reservoir, and serves to even out the heat distribution.

As can be seen in our illustration the cylindrical



Sintering furnace, rated at 25kW, for temperatures up to 1650 deg. Cent.

furnace casing is constructed of mild steel plate fitted with removable end covers. At the charging end, an extended solid drawn tube acts as a preheat-purging chamber; the exit chamber is water-cooled to ensure that a charge is below oxidation temperature before leaving the furnace.

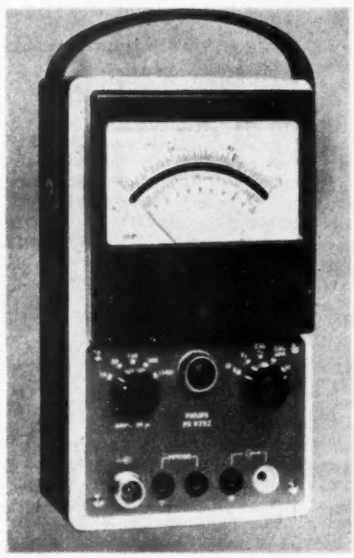
Atmosphere of hydrogen or cracked ammonia is fed through an inlet under the furnace to distribution pipes in the thermal insulation in the base. The gas percolates through the insulation absorbing heat and is, therefore, preheated before entering the work tube. Auxiliary inlets are provided in the main furnace casing and between heating and cooling chambers to allow an increase in the gas flow when doors are opened for charging or discharging. A "burn-off" at both doors consumes excess hydrogen and prevents ingress of oxygen.

The furnace is rated at 25kW and in it the heating is divided into two independent, automatically controlled zones along the length of the chamber. Automatic temperature control equipment on a separate control desk comprises three position-indicating temperature controllers operating motorised voltage regulators giving stepless variation of the low voltage element supply. By this means the current is not switched off when controlling at the preset temperature. The secondary voltage of the motorised regulator is automatically adjusted so that the power input to the furnace balances the consumption.

[Reply Card No. E8312]

Direct-Reading Vibration Meter

WE have received details from Research and Control Instruments, Ltd., Instrument House, 207, King's Cross Road, London, W.1, of a Philips direct-reading vibration meter (PR 9252) for which the company is sole distributor in the United Kingdom. The instrument embodies a transistor amplifier which is supplied from a battery of five nickel-cadmium cells, and also contains a built-in charging rectifier so that the battery may be recharged from the mains. It operates in conjunction with transducers (sup-



Vibration meter incorporating transistor amplifier with battery supply and charging circuit

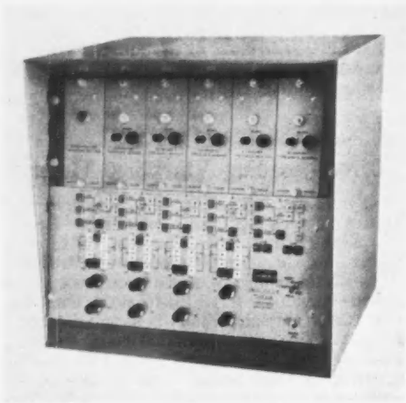
plied separately) for absolute or relative vibration measurement and gives readings on a scale calibrated directly to show peak amplitude in microns. Five measuring ranges cover 0 to 1000 microns. Sockets are provided for displaying vibrations on an oscilloscope, and in every range a calibration voltage may be obtained to assist evaluation of the waveform. A phase-indicator may also be connected.

The circuit comprises a calibrated attenuator, selector switch and R.C. circuit for integrating the transducer voltage (proportional to acceleration) to speed, followed by a transistor amplifier with feedback, and a bridge rectifier. We illustrate the instrument, which measures approximately 8¾in by 5¼in by 4in and weighs 5½ lb.

[Reply Card No. E8313]

Computer Training Device

A SIMPLIFIED analogue computer for instructional purposes has been introduced by the Solartron Electronic Group, Ltd., 45, Thames Street, Kingston, Surrey. In the accompanying illustration of this unit, known as the "TY 963 Analogue Tutor," the five d.c. amplifiers are seen at the top of the cabinet, with the patch panel below. Component and voltage values have been chosen for simplicity in setting up problems, and the unit is capable of representing any form of the linear second order differential equation with its built-in facilities. Other component values may be obtained in the usual manner by connections to the patch panel, and the same method enables the work which may be undertaken to be extended. For example, using external diodes as additional computing



Simplified analogue computing unit for instruction of users

impedances, the effects of velocity and acceleration limits may be demonstrated.

Within the limitations imposed by the complement of five amplifiers, a wide range of physical systems may be represented. These include simple servos, electrical networks, the motion of a particle under gravity, and so on. The unit will suffer no permanent damage should incorrect operation be programmed by unskilled users. Component assemblies are interchangeable in common with all Solartron "Space" series analogue computers, so that elements from the Analogue Tutor may be incorporated into more complex analogue computer installations at any time should this be required.

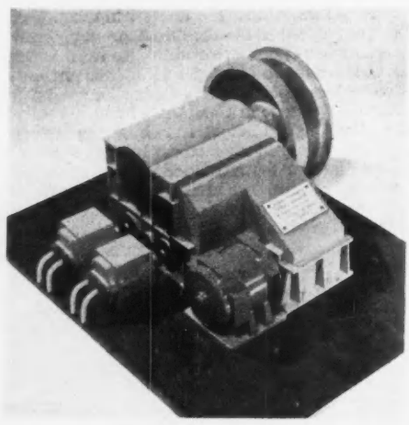
[Reply Card No. E8321]

Cable Machinery for G.P.O. Cableship

WE illustrate a model of the new Telcon-Hindmarch cable engine to be installed in the British Post Office cableship being built by the Fairfield Shipbuilding and Engineering Company, Ltd. The contract for the supply of the whole of the cable machinery and cable handling gear for this ship has been placed by the builder with Submarine Cables, Ltd. (owned jointly by Siemens Edison Swan, Ltd., and The Telegraph Construction and Maintenance Company, Ltd.). Design and manufacture of this equipment, which is to be completed by November next year, will be the responsibility of the "Telcon" Engineering Division, and will be carried out at Greenwich.

The two forward picking-up and paying-out cable engines, each weighing approximately 50 tons, will be of the design illustrated and will be arranged so that both port and starboard gears can pick-up or pay-out over the bows, whilst the port gear can also be used for laying cable over the stern. The diameter of the cable drums is 7ft on the tread. Each cable engine will be powered by a 250 h.p. d.c. electric motor fed from a ring main and capable of being used regeneratively when cable is being paid out. Four choices of gear ratio are available in the cable engine drive, all gears being in constant mesh and engaged or released through hydraulic clutches. The entire gear train, running in ball and roller bearings, is totally enclosed and oil-sealed and, together with the remote-controlled oil-operated clutches, is the product of Modern Wheel Drive, Ltd., who has designed it to "Telcon" requirements.

Each cable engine is capable of picking up



Arrangement of picking-up and paying-out cable engine with 250 h.p. driving motor. Two hydraulic braking units are seen on left

cables as follows: 30 tons at 1 knot (100ft per minute); 15 tons at 2 knots (200ft per minute); 7½ tons at 4 knots (400ft per minute). Both port and starboard engines are designed to pay out cable over the bows at a tension of 0–9 tons at any speed from 0–8 knots (0ft–800ft per minute). The port gear is also designed to pay out over the stern at the same tension and speeds.

Three forms of braking are to be employed to share the braking load or, independently, to sustain the cable tension by the use of (*a*) the 250 h.p. electric motor as a regenerative brake; (*b*) two V.S.G. oil-operated variable tilt braking units, and (*c*) by a combined main holding and water-cooled pay-out brake of special design, acting on the cable drum. All controls will be grouped on the upper deck in a console.

[Reply Card No. E8322]

Electronic Sub-Assemblies

THE extent to which the "building brick" principle has been applied to electronic apparatus was demonstrated at an exhibition held in London recently by Mullard Equipment, Ltd., Mullard House, Torrington Place, London, W.C.1. Demonstrations were given of practical applications of the "Combi-elements" and "Norbits" described in our November 20 issue. One of

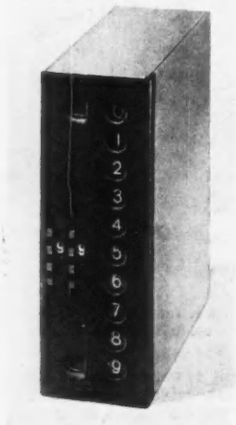


Fig. 1—Counter with cold-cathode tube display and two programme channels with rotary presetting switches

these showed "Combi-Elements" used to count the number of revolutions made by a shaft and at the same time to determine the direction in which the shaft was rotating. The "Norbit" demonstration showed these static transistor switching elements combined to form a logic unit for recognising signals from a small matrix of photo-transistors arranged to "look at" passing objects. In this way specific shapes could be recognised and counted, and an alarm could be given if a predetermined sequence of shapes was varied.

Other working demonstrations illustrated applications of the 88930 series of preset counters with programming facilities. The basic unit in this series provides a decade of counting at speeds up to 2000 a second, using cold-cathode trigger

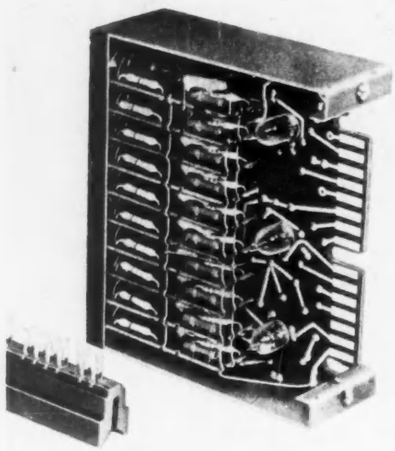


Fig. 2—Interior of counter showing cold-cathode tubes and printed wiring to connector block (shown detached). The connector pins are gold-plated

tubes which by their glow discharges give a visual indication of the count registered in the "windows" on the front of the unit. Two independent programme channels may be preset by means of rotary switches, and in the demonstration these were set to issue "slow down" and "stop" signals to a conveyor at different stages of the count. Additional plug-in units may be added to increase the number of programmes available to a maximum of ten. Both these counter "building bricks" have uniform dimensions of 4·5in high by 4·1in deep by 1·5in wide. In Fig. 1 are seen the "windows" illuminated by the cold-cathode tubes to show the count registered, and the two rotary programme switches of a decade unit. Extensive use is made of printed circuits (Fig. 2), and sub-units constructed on this principle are incorporated in the main units or may be applied separately. A multi-programme timer comprising four decade units and using six programme channels was demonstrated, enabling six separate actions to be initiated at any required points in the range 0–999 (or, with special switching arrangements, 0–9999).

A second counting demonstration showed the use of 88929 series counters for general purposes where the counter is not required to produce command signals for control purposes. In the basic unit an E1T decade tube, giving visual indication of the count, provides counting speeds up to 30,000 a second. Add-on units are available to increase the speed to 100,000 a second, and other plug-in ancillary units may be added on the "building brick" principle. All are of standard dimensions (4·6in high by 1·5in wide by 3·9in deep). An assembly of these units was shown forming a differential tachometer to measure the speed of a motor shaft and also the percentage slip between this shaft and a second shaft pulley-driven from the motor.

[Reply Card No. E8323]

Industrial and Labour Notes

Wages and Hours

Last week representatives of the unions comprising the Confederation of Shipbuilding and Engineering Unions discussed the replies of the shipbuilding and engineering employers to the recent claims for a wage increase and a reduction of the working week to forty hours. The shipbuilding employers, it will be recalled, rejected the wage claim and said that they were willing to discuss a reduction of the working week provided they could be assured of greater co-operation from the unions on the vexed question of restrictive practices. The engineering employers, on their part, offered a working week of forty-two-and-a-half hours in settlement of both claims. The union confederation's executive was not prepared to accept either offer.

At last week's delegate conference, the executive's attitude was endorsed. At the same time, the executive was enjoined "to pursue vigorously the claims submitted." This implies that the union confederation's executive is now free to make another approach to the Shipbuilding Employers' Federation and the Engineering and Allied Employers National Federation with a view to a satisfactory settlement of the claims.

Overseas Trade

The Board of Trade reports that exports of United Kingdom manufactures and goods in November were valued at £298,300,000. The value of imports in November was £357,100,000 and of re-exports £9,500,000. The Board says that, after eliminating "normal seasonal variation," the monthly average value of exports between January and November this year was 4½ per cent above the monthly average for 1958. On the same basis, the monthly average value of imports was 6 per cent higher.

Iron and Steel

British steel production in November was about 30 per cent higher than a year earlier. At a weekly average of 458,600 tons, output was running at an annual rate of 23,847,000 tons. Pig iron production in November averaged 277,300 tons and was thus at an annual rate of 14,422,000 tons, compared with 12,155,000 tons a year earlier.

The Iron and Steel Board says that, in November, steel producers were operating at about 95 per cent of their capacity. The gradually broadening basis of recovery in the industry is reflected in the October delivery figures. Apart from the continued increase in steel deliveries to the motor-car industry, there has been marked expansion in deliveries to the building and constructional engineering industry and to the general engineering industry. During October, deliveries of almost all descriptions of steel were higher than in September. Steel stocks held by merchants and consumers at the end of the third quarter were calculated at 3,458,000 tons, or 148,000 tons less than at the end of the second quarter. This drop, it is stated, is larger than the normal seasonal fall for the third quarter; it indicates that stocks are still being run down, although at a diminishing rate. The Iron and Steel Board thinks that this suggests an upward movement in steel stocks before the end of this year. Based on the seasonally low rates of consumption in the third quarter of the year, consumers' stocks at the end of September amounted to 13·2 weeks' usage compared with 17·3 weeks a year earlier. Stocks held by public organisations fell during that period from twenty-seven weeks' consumption to twenty-four weeks, and stocks held by private firms from sixteen weeks' to twelve weeks' consumption.

Steel Works Development

The Steel Company of Wales, Ltd., has announced a further plan of development which is designed to increase its annual production of ingot steel to 3,650,000 tons by the end of 1961, with consequent increases in sheet and tinplate production. This plan, the cost of which is estimated at about £30,000,000, is additional to the company's third development programme, work under which is now approaching completion.

The new plan does not include any further additions to coke ovens, blast furnaces or steel melting shops but certain modifications will be made, in the light of experience already gained, to give increased efficiency and performance. A continuous casting plant is to be installed for the production of steel slabs and a 48in wide hot strip mill is to be built alongside the existing 80in hot strip mill. This, the company says, is an arrangement which will give greater flexibility as well as a measure of reserve capacity. By this new arrangement, it will be possible to roll on the wide mill additional quantities of the sheet required by the motor-car industry and to utilise the narrower mill for the production of steel coil for tinplating as well as for other purposes. The new 48in mill, it is stated, is likely to be manufactured in Scotland. Additional finishing equipment is to be installed in the Abbey Works to deal with the increased output of steel sheet for the motor-car and other industries. The new plan, it should be noted, has been approved by the board of The Steel Company of Wales, Ltd.; it has now gone to the Iron and Steel Board for approval.

Technical Education and the Human Factor

The fourteenth report of the Nuffield Foundation comments on the establishment, at Brunel College of Technology, Acton, of a research unit for psychological and social research on problems of technical education and human factors in industry. The Foundation has made a grant of £15,000 towards the cost of this research. The unit is to have a full-time research and technical staff and the senior members of the management and production engineering department's teaching staff will share in the work.

This new research unit plans, as one of its studies, to trace ways in which students' attitudes to work develop during their progress from school through the academic and industrial phases of sandwich courses. All students will be interviewed three times: on entering college, at the end of the first college period, and at the end of the first industrial period. Further data will be sought by interviews with a selected sample of students to arrive at a deeper understanding of the motives and processes affecting a student's learning. The aim is to discover the significance to the students of their industrial experience as well as its objective pattern, the developments in the students' professional interests, aspirations and sense of competence and the changes, if any, in their values and outlook relevant to their careers. In fact, the study will consist of a comparison of attitudes, values and behaviour at crucial moments in the educational process. The conclusions, it is hoped, will be useful to industry and college for the clarification of their respective roles in the joint educational enterprise.

Scotland's Natural Resources

The Scottish Council (Development and Industry) has announced that an inquiry is to be made into Scotland's primary resources, which include people, land, water, fuel and energy, minerals, fish and wild life, and forestry. This inquiry is to be steered by a newly-appointed Committee on Natural Resources in Scotland, the chairman of which is Mr. L. A. Elgood. The committee's terms of reference are: (i) to form a fact-finding study group on natural resources (including human resources) and make recommendations, and (ii) run a series of operations based on the study group's findings, which might lead to the provision of a permanent body in Scotland such as a centre for resource development transactions and authoritative information. One of the committee's objectives is to see established an organisation which can provide basic resource information and be of use to the research and development departments of industrial companies.

The Scottish Council recalls that the United Nations Scientific Conference on the Conservation and Utilisation of Resources (U.N.S.C.C.U.R.) has emphasised that a country must know how to make the best possible use of its resources. To do this, of course, it must first know its resources and then know how to manage them. In announcing the inquiry, the Scottish Council has pointed out that Scotland has an abundance of natural endowments in the form of coal and other minerals. Although some of these, such as oil-bearing shale, have been exploited, others can, through research, form a source of wealth in the future. The "continuing drainage" of Scotland's human resources through emigration is also commented upon. At present, the Council says, about 40 per cent of Scottish graduates in science and 60 per cent in engineering leave Scotland. The present rate of emigration of trained men, it is emphasised, is too high and is of serious concern to those interested in the well-being of Scotland.

The inquiry will have three main groupings, namely, land resources, human resources and fuel and energy. The procedure proposed is initially, a fact-finding study group to be followed a year later by a conference of wider educational scope. The problem, the Scottish Council comments, lies in resolving the best way in which to develop the resources which Scotland has and, if necessary, in justifying the establishment of research laboratories to strengthen fields of inquiry which can be shown to require strengthening.

Rotary Four-Stroke Engine

RECENTLY, the N.S.U. Company of Neckarsulm, released details of a revolutionary design of rotary-piston motor, named, after its inventor, the N.S.U.-Wankel engine. The wide range of applications which its originators foresee is underlined by the interest shown for this design in America, where the Curtiss-Wright Company has acquired a licence and is carrying out its own development work in co-operation with N.S.U. It would appear, if further work bears out the earlier results, that a major step forward has been taken in the design of internal combustion engines.

In trying to estimate in what the importance of the improvement lies, we must take a look at the competition which the new engine has to face. The reciprocating internal combustion, an offspring of the steam engine and the later gas engine, has during the eighty-odd years of its existence undergone an enormous degree of refinement with regard to layout, materials, and manufacturing method, not to mention the large number of minor original inventions which have all contributed towards the reliable, cheap, and reasonably efficient power unit of to-day. Why, in fact, should one wish to go beyond it ? The answer, as is well known, lies in the basic mechanical and thermal limitation imposed on the power/weight ratio ; the piston rings will seize and the valves will burn up as the thermal loading is stepped up ; the valve gear and other reciprocating parts will fail at high rates of revolution under inertia forces which increase as the square of the rotational speed.

The idea of doing away with reciprocating motion is not new. The earliest known designs, in fact, go back to Amontons (1699) and Leupold (1723), and James Watt, between 1782 and 1788, worked on steam engines with rotating pistons, but like so many others since then, failed to solve the sealing problem. His collaborator, Murdock, in 1799 used the gear pump (invented by Pappenheim in 1636) as a steam motor (and discovered its very poor efficiency in this application). Since those days, although many people tried to develop a rotary piston engine, none of their efforts met with success.

Our sectional view (Fig. 1) shows the design of the N.S.U.-Wankel engine. Inside a water-cooled casing *A*, concentric with the output shaft *B*, revolves the rotor piston *C* about an axis which is parallel but eccentric in relation to *B* and also revolves about *B*. This piston, which makes a gastight fit against the end plates, has the shape of an equilateral triangle with sides approximating the arc of a circle. The apices continuously sweep over the inside surface of the casing *A* which takes the form of a double epi-trochoid. A gastight contact is again maintained between *A* and the corners of *C* by means of special sealing strips incorporated in *C*, which are analogous to the ordinary piston rings. The rotary motion of the piston is transmitted to the output shaft by the internal gear *D* which meshes with a pinion on the shaft (not shown in Fig. 1). A balancing mass *E* and flywheel *F* are provided to compensate the inertia forces arising from the planetary motion of the piston and to provide more even running. Inlet and exhaust ports are situated in one of the end plates and connected to the inlet ducts *G* (equipped with carburettor and air filter, *H*), and the exhaust duct *J*. The spark plug, *K*, is also mounted in the end plate. Cooling water connections are seen at *L* and *M*. It may be pointed out here—we shall return to this matter later—that this arrangement of a stationary casing housing a revolving piston is actually the kinematic inversion of the original design in which both piston and casing rotated.

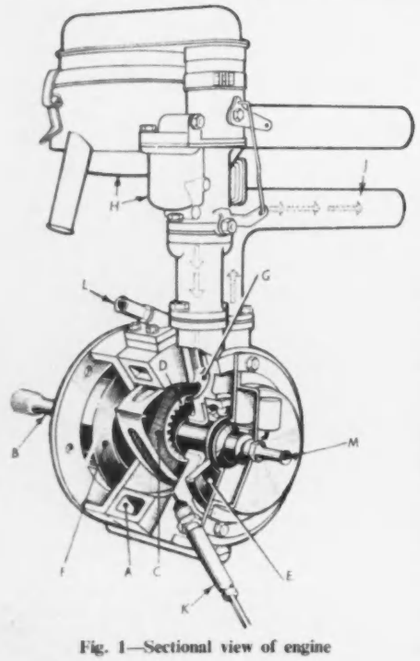


Fig. 1—Sectional view of engine

The principle of operation is explained with reference to Fig. 2 which represents a diagrammatic section during a complete revolution of the output shaft. Since the piston, while being rotated forward, counter-rotates at two-thirds of the shaft speed, its actual speed relative to the casing is only one-third that of the shaft, a fact which is significant as it implies a comparatively low sliding speed even at a high rate

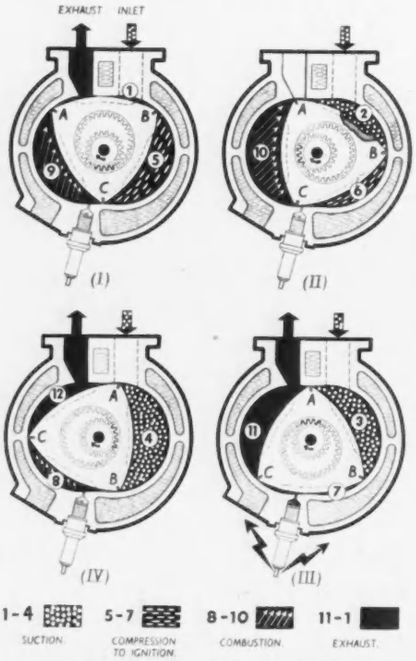


Fig. 2—Diagrammatic section of N.S.U.-Wankel engine, illustrating the principle of operation. The stages (I) to (IV) follow in that order

of revolution of the output shaft. It also means that there is one working "stroke" during each revolution of the shaft.

As may be seen from the diagram, the piston or rotor intercepts three spaces between its faces *AB*, *BC*, and *CA*, and the epi-trochoidal inner surface of the casing. As the piston rotates, these spaces grow and diminish, rather like the volume inside the cylinder of a reciprocating engine as the piston moves up and down, but with a mutual phase difference of 120 deg. While one working space, say *AB*, is in the suction phase (1–4), the next, *BC*, is undergoing compression and ignition (5–8), while the third, *CA*, goes through the stages of expansion and exhaust (9–12). The cycle is therefore a true four-stroke cycle.

The principle of a triangular rotor revolving in the manner described in relation to an outer casing with a curved contact surface was invented by Mr. Felix Wankel, a sealing specialist who, between 1936 and 1945, had carried out development work connected with rotary valves at the German Aeronautical Research Establishment DVL. In 1951 he began his co-operation with the N.S.U. research department under Dr. Walter Froede and Dipl.-Ing. Höppner. Wankel completed his first design in April, 1954 ; the exact shape of the curve of the casing was established by Professor Baier of Stuttgart Technical University, who also designed a special grinding machine for producing it. The design was investigated by building models and pumps and compressors. It may be mentioned that Baumm's record-breaking "deckchair" motor-cycle of 1956, which reached 196km per hour on the Utah salt flats, was powered by an N.S.U. "Quickly" two-stroke engine of only 50 c.c. capacity which was supercharged by one of the early Wankel blowers ; its output amounted to 13 b.h.p., or 260 b.h.p. per litre.

The first prototype of 125 c.c. chamber volume was tried on the test bed on February 1, 1957, and long-firing sequences were immediately obtained. The specific consumption of this early engine was of the order of 250 grammes per brake horsepower per hour. Subsequent refinement of the sealing and the cooling system reduced this figure to 230 grammes per brake horsepower per hour. Mean effective pressures up to 8·5 kg per square metre were obtained giving outputs of 29 b.h.p. at 17,000 r.p.m. of the casing (11,300 r.p.m. of the rotor), with satisfactory power even at speeds as low as one-tenth of this.

In the early engine both casing and piston had been rotating, but it was then decided to invert the design, keeping the casing stationary and superimposing on the piston rotation the counter-movement of the eccentric. This counter-rotation of the eccentric means that the actual sliding velocity is only the difference between the speeds of the piston and eccentric, thereby maintaining the wear of the sealing surfaces on their reasonable limits. Models of this design of 125 c.c. and 250 c.c. began to be tested early in 1958.

No valves or valve gear are required with the new engine, since the rotating piston itself covers and uncovers the inlet and exhaust ports in turn. The whole design thus assumes an extreme degree of simplicity and compactness, as only two moving parts are involved. This is vividly shown by the fact that, even though it is not a special pared-down design, the 125 c.c. prototype weighs only 17 kg in cast iron and steel, and 11 kg in light alloy (Fig. 3). By the positive division of the working spaces due to the adoption of four-stroke operation, even running at all loads and low specific consumption are obtained. The adequate cooling and absence of hot spots make the engine insensitive to a low octane number.

Fig. 3—125c.c. prototype rotary piston engine

Roadbuilding Machines

AMONG plant for the construction of roads built by Dinglerwerke Aktiengesellschaft, Zweibrücken, may be mentioned the "BfM" profile. These attachments can be raised hydraulically so that the machine can traverse rough ground without damage.

Fig. 1—Front view of spreader/tractor for spreading ballast and macadam

paver-finisher which is shown in our illustration (Fig. 1).

This is a machine specially designed to make possible a simple and quick change-over from spreading ballast to laying bituminous surfaces and vice versa. It consists of a pneumatically-tyred tractor to which trailer-mounted equipment is attached. (Alternatively, the tractor can be used for general traction purposes.) It is powered by an air-cooled 27 h.p. Deutz diesel engine and is fitted with all-wheel drive; there are five forward speeds from 2km to 18km per hour, and one reverse gear of 4km per hour. In addition, five forward working speeds of 1·5m to 11·4m per minute are obtainable, together with one reverse speed of 2m per minute. The steering is hydraulically assisted. The total weight is 3·8 tonnes.

The ballast spreader has a working width of 2·5m and a maximum depth of 17cm. Together with the tractor the total weight is 5·2 tonnes. The machine is fitted at its front end with rollers by means of which it pushes a lorry in front of it which tips ballast, sand, or coated macadam into the hopper of the attachment, from where it falls on the ground through an adjustable gate. A grader blade fitted at the rear end then planes the ballast to the required height and

In order to convert the machine to coated macadam laying, the grader is raised and locked in that position. The machine can then be connected to the macadam distributor by means of a spherical bolt and universal shaft drive. The whole of this operation is stated to require only about thirty minutes. The equipment works as follows: as with ballast, the coated macadam is tipped into the hopper, and by means of the adjustable gate is deposited on the road to the required depth, leaving the wheels of the vehicle free. Helical screws distribute the material sideways to the required width which can be up to 3·75m (Fig. 2).

The heavy vibrating roller (Fig. 3) can be used with this equipment acting as tractor, or in conjunction with an ordinary tractor. With a static weight of only 3·5 tonnes, the roller exerts an effect of up to 33 tonnes. Particular attention has been paid to obtaining a large roller diameter and working width, viz. 1200mm and 1720mm, respectively. As an example of what the roller can do, the firm quotes a series of trials with only lightly binding, fine to medium sand in layers of 50cm to 70cm thick. The particle size was 0·02mm–1mm and the coefficient of uniformity lay between 2 and 5. The optimal water content was given as 11 to 13 per cent, and the specific dry weight was 1·860 tonnes per cubic metre for a Proctor density of 100 per cent. In spite of these unfavourable conditions, it proved possible to achieve in three to four passes Proctor densities of 97·9 to 102·8 per cent at depths of 25cm to 40cm.

Our illustration (Fig. 4) shows a machine

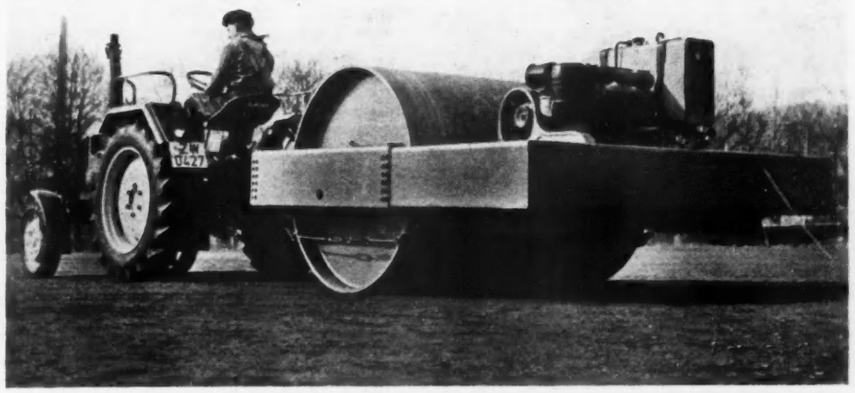


Fig. 3—Trailing roller of 3·5 tonnes static weight. The vibrating roller exerts an effective ground thrust of up to 33 tonnes

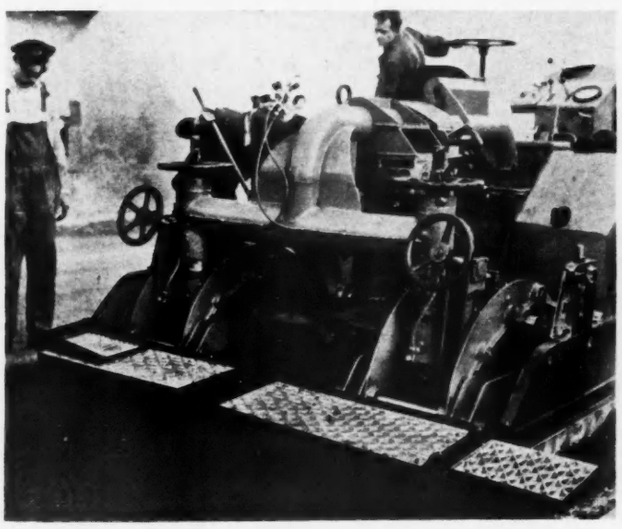
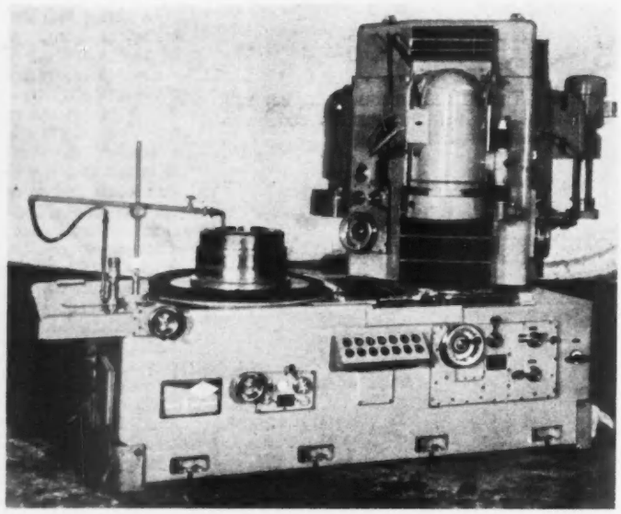


Fig. 2—Macadam spreader attached to the rear of spreader/tractor

Fig. 4—Joint grinder in operation, cutting joints into a concrete road surface

made by the same firm for cutting joints in natural stone, concrete, and asphalt surfaces. With cutting wheels up to 450mm in diameter and wheel widths of 6mm to 20mm, any cutting depth up to 115mm can be obtained. The wheels can easily be exchanged. The feed is done by hand. The performance of the machine may be illustrated by the following example. In the case of three-months-old "Autobahn"- concrete to German Standard Specification B 500, i.e. concrete having a strength of 500 kg, and made with gravel obtained from the river Rhine, the cutting speed amounted to about 30m–35m per hour with a joint depth of 50mm and a joint width of 8mm–10mm. A pump mounted on the machine supplies cooling water to the cutting disc. The tension of the spring which pushes the grinding disc against the concrete to be cut is indicated to the operator, who thereby is able to find the most favourable rate of speed after cutting a short test stretch. In order to maintain a true straight line, guide tracks are supplied with which rollers on the machine are brought into engagement. It is of course possible, and sometimes more economical, to operate without the guide tracks, for instance when cutting longitudinal joints in curved stretches.

The machine is powered either by a 30 h.p. VW petrol engine or a 20 h.p. Deutz diesel engine. Only one man is required for its operation.



Grinding machine with three heads on an indexing column to allow internal, external and surface grinding of a component at one setting on the work table

Three-Head Grinding Machine

For some years, Hans Sielemann, of Bünde-i-W., Germany, has made a rotary table grinding machine with two grinding heads—one for surface and the other for internal grinding—mounted on a rotatable column at the side of the table. The object of this construction is to promote economy in space and speed in production by enabling two grinding operations to be performed in succession at one setting of a component on the rotary table. To further increase the capacity of this machine, it is now available, as shown in our illustration, with a column having a third head for external grinding operations. Thus, by indexing the column, the successive operations of internal, external and surface grinding can be carried out on a component on the one machine. These machines are made with four sizes of rotary work tables of from 600mm to 1300mm diameter and having permissible table loadings from 150 kg to 1000 kg.

The rotary work table assembly is carried on large slideways on the base of the machine and is driven by a hydraulic motor giving a stepless range of speeds. Its spindle assembly incorporates a hydraulic pressure chamber in which an upwards pressure of oil is maintained to limit automatically the loading of the table on its flat ways to about 50 kg, irrespective of the weight of the workpiece. Precision work infeed measurement equipment is fitted on the table slide and, if required, a table tilting mechanism can be incorporated to effect conical grinding of components.

At one end of the main casing there is bolted a fixed support upright on which the rotatable column carrying the grinding heads is located through annular tapered bearing surfaces at the top and bottom. Whilst grinding is in progress, the column is clamped firmly down on the tapered faces of the upright by hydraulic clamps. When it is required to index the column to bring another grinding head into the operative position, the action of releasing oil pressure from the hydraulic clamps diverts pressure oil into a lifting cylinder. This cylinder raises the column by about 0·02in to disengage the respective taper surfaces and leave the column suspended on a ball thrust bearing assembly at the top of the upright. The column can then be freely turned by hand to bring the required grinding head into position before the clamps are again applied.

Each of the slides carrying the grinding head units, complete with their drives, on the column is actuated over its vertical stroke by variable speed hydraulic motors, automatic reversing equipment being fitted for the cylindrical and internal grinding head slides. The grinding head assemblies are counterbalanced by hydraulic cylinders to relieve the weight on the slide traversing spindles.

Conrad Matschoss Competition, 1960

The importance of technological history is especially great in a period of rapid development like the present. Particularly is this the case in connection with the training of young engineers. This view was emphasised time and again by the late Dr.-Ing. E.h. C. Matschoss, himself a technical historian of distinction, who for many years directed the Association of German Engineers (V.D.I.). It was his suggestion that older engineers should make available their recollections of events in their careers which, going beyond the personal experience, were of general importance to technical history. In order to further such contributions, the V.D.I. is offering a biennial essay prize for which all persons are eligible, including non-V.D.I. members and non-German nationals.

Contributions must be in German, not exceeding about 3000 words in the case of memoirs and twice this length in the case of historical theses ; they must be sent under a code name not later than July 1, 1960, to the Verein Deutscher Ingenieure, Düsseldorf, Prinz-Georg-Strasse 77/79, from which fuller particulars may be obtained on request.

Combustion and Propulsion Colloquium

The Combustion and Propulsion Panel of the Advisory Group for Aeronautical Research and Development, N.A.T.O., will hold its Fourth Colloquium in Milan, Italy, during the week of April 4, 1960. The five-day meeting will be devoted to discussions on " High Mach Number Air-Breathing Engines."

Among scientists who will participate will be Dr. Theodore von Karman, chairman of A.G.A.R.D., Monsieur Maurice Roy, French national delegate to A.G.A.R.D. and Director General of O.N.E.R.A., and Dr. Giuseppe Gabrielli, Italian delegate to A.G.A.R.D., manager Aircraft Division of Fiat and Professor of the School of Aeronautical Engineering at the Polytechnic Institute of Turin.

The opening session will consist of a round table discussion on " The Future of Air-Breathing Engines." In addition to civilian speakers from several of the N.A.T.O. countries, a few outstanding military authorities have been invited to summarise the current views of the armed forces.

During the remaining four days, the following themes will be developed in invited papers from Germany, Italy, the United Kingdom and the United States : performance and applications ; hypersonic inlet studies ; supersonic combustion and detonation ; nozzle flow with chemical reactions ; rotating machinery ; and high temperature material problems.

Although the meeting is unclassified from a security viewpoint, attendance is limited to those who are authorised to attend by either the A.G.A.R.D. national delegates, or by members of the A.G.A.R.D. Combustion and Propulsion Panel.

Quick-Action Water Heater

A 2kW electric water heater for the rapid production of hot and even boiling water and with a capacity of 5 litres has been put on the market by Siemens Electrogeräte Aktiengesellschaft, Berlin and Munich. It comprises a copper cylinder, internally tin-plated and stove-enamelled on the outside, which is connected to the water supply by means of a special control device. In front of the cylinder is mounted a calibrated water level gauge and the combined switch and temperature preselector button. It is not necessary to heat the whole contents of 5 litres, but any lesser quantity, as shown on the gauge, can be heated.

The control comprises a shut-off cock and three-way valve, which are used for filling the container and drawing off hot, cold or mixed water. After filling, the desired temperature is set with stepless adjustment and the starting button is pressed. A signal lamp lights up and is extinguished when the water has reached the required temperature. The heater then automatically switches off, except when boiling water is required, when switching off must be by hand. Boiling is indicated by an acoustic signal ; 1 litre can be brought to the boil in four minutes. The swivel draw-off pipe is thermally insulated to protect the hand. At the top of the cylinder a cap is provided for adding anti-scaling compounds. A special cut-out protects the heater if it should boil dry.

German Nuclear Developments

The hope has been expressed by the Federal Ministry for Nuclear Energy that the Government's nuclear energy bill, together with the constitutional amendment necessary for its enactment, will be passed before the end of this year by the Bundestag with the two-thirds majority required.

On November 20, the draft law was finally approved by the Bundestag committee for nuclear energy. Its passage into law will remove many uncertainties which until now have hampered the development of the German nuclear industry.

Federal efforts to help nuclear industrial progress are reflected in the 1960 budget of the Ministry for Nuclear Energy. This increases the funds provided for modernisation and extension of scientific installations to DM.50,000,000, as compared with DM.44,000,000 this year.

Spending for protective measures against radiation hazards will rise from DM.3,000,000 during the current year to DM.4,800,000 in 1960. For the planning and construction of experimental reactors the budget sets aside DM.16,700,000, over three times this year's expenditure. The Gesellschaft für Kernforschung m.b.H. (Society for Nuclear Research), in Karlsruhe, will get DM.25,500,000 instead of DM.10,000,000 in 1959. In addition, the Government's contribution to the construction of an electron-synchrotron in Hamburg will go up from DM.5,200,000 to nearly DM.21,000,000. It is now estimated that the total cost of this important research installation will reach about DM.60,000,000.

Spectroscopic Studies of Trapped Radicals

BY OUR AMERICAN EDITOR

The National Bureau of Standards has studied spectroscopically the light emission from a variety of free radical species produced in the excitation of nitrogen, oxygen and other condensates. Two methods of free radical production were employed to provide an understanding of free radical behaviour, a subject which is presently receiving a great deal of attention throughout Government and industry.

TO provide basic data on the properties and behaviour of stabilised free radicals, the National Bureau of Standards, Washington, D.C., under the sponsorship of the U.S. Department of Defence, has made an extensive spectroscopic study of highly reactive atoms and excited molecules trapped in solids at low temperature. A number of methods are available for producing such electronically excited molecules and atoms in solids at low temperatures. The Bureau employed primarily two techniques in order to present a consistent over-all picture of observations. In one aspect of the work, the N.B.S. Free Radicals Section investigated reactive fragments condensed from nitrogen gas passed through an electric discharge. In the other phase of the study, nitrogen atoms were produced by the electron bombardment of nitrogen condensed on a cold surface. Analogous studies with oxygen were made by another group.

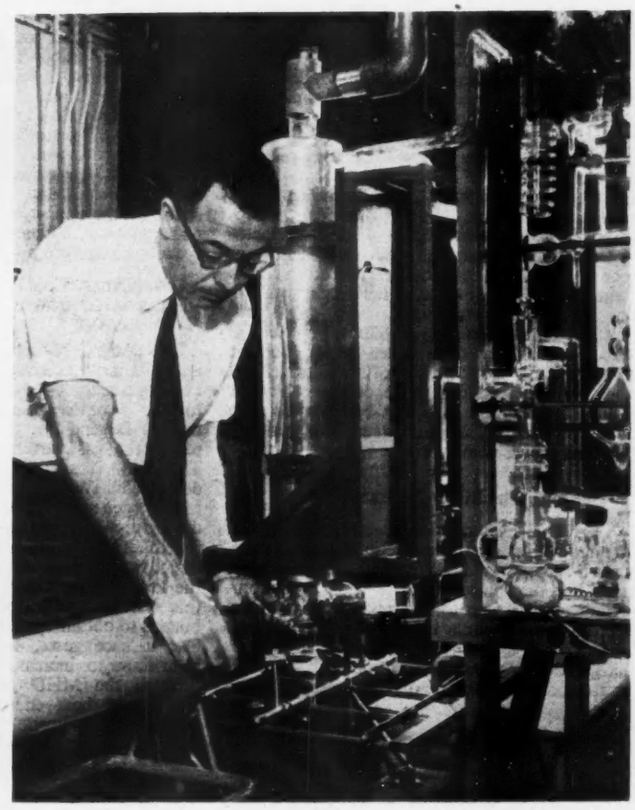
Free radicals have been known to exist for about thirty years but only lately have they become the object of widespread interest. The National Bureau of Standards is now engaged in a three-year programme of free radical studies. In most of this work, free radicals have been produced by the discharge technique mentioned above. The glow phenomena observed here were found to be quite similar to those observed in early work where free radicals were produced by electron bombardment. This led the Bureau to repeat both experiments to provide a complete set of data on radical behaviour. Tne apparatus used in studying the products of a gas discharge is quite simple in principle. Gaseous nitrogen flows through a quartz tube in which an electrodeless microwave discharge is maintained by a waveguide. The products from the discharge are condensed on a block cooled by liquid helium or hydrogen. The light emitted by these discharge products emerges through quartz windows and is analysed by glass- and quartz-prism and grating spectrographs and an infra-red spectrometer.

In studying free radicals generated by electron bombardment, nitrogen is first condensed on a metal surface cooled to 4 deg. K. by means of a liquid helium bath. This surface is then used as an electron target, and in the bombardment free radicals are produced. Windows allow the glow phenomena to be observed visually and with spectrographs. Glass prism spectrographs, quartz prism instruments and a transmission grating instrument were used. Light emission, which can be attributed to nitrogen atoms and molecules, is observed in three distinct periods in each of the studies. First, there is the glow during deposition or bombardment. This is immediately followed by an afterglow when excitation has ceased. Later a warm-up glow appears as the coolant evaporates and radicals are released. The main properties of the spectra obtained by the two methods are very similar. This agreement leads to the conclusion that only certain excited states are capable of radiative transitions.

Through spectral observations of the emitted light it has been possible to separate most of the features of the solid glows into atomic and molecular transitions and to identify many of the emitters. An interpretation of one of the strong spectral features indicates that emission is due to a loosely bonded complex of N and N_2. With this model it is possible to characterise the observed emission as simple combinations of electronic transitions of the nitrogen atoms and of vibrational transitions of the N_2 molecules. For example, one particular line group observed in both studies corresponds to an identifiable transition of a trapped atom. An associated line group seems to correspond to the same transition with the N_2 molecule in a vibrationally excited state.

Under special conditions, spectral lines appear which are attributed to one of the transitions of atomic oxygen. In this case, oxygen atoms are thought to be trapped in a weakly bonded N_2-O complex. However, this picture of a loosely bonded complex, so effective in explaining atomic lines, does not apply in interpreting some other observations, such as the molecular features strengthened or introduced when impurities are added to the nitrogen. A pure nitrogen spectrum consists mainly of atomic features (lines) which are not significantly affected by the addition of other gases such as oxygen and argon. On the other hand, such components have a very definite effect on molecular features, increasing the intensity of some and introducing still others. For example, argon in large amounts greatly increases the intensity of the Vegard-Kaplan bands which were first observed and identified in the initial production of nitrogen free radicals thirty years ago. Under other conditions two sets of bands, which can be traced to the NO molecule, appear. In nitrogen containing hydrogen or water vapour, bands appear which are interpreted as transitions of the NH radical.

The emission spectra from an electron-bombarded deposit of a rare gas and oxygen were studied between 1·1 deg. and 20 deg. K.:



(Left) Electron bombardment apparatus for generating free radicals, with electrons from the electron gun in the foreground impinging on a helium-cooled nitrogen-coated target inside the cylindrical cryostat. (Right) Electron bombardment apparatus for studying the light emitted by cold surface deposits of a rare gas and oxygen when bombarded by electrons

this analysis provides information about the interaction between the reactive species and the solid matrix. For example, wavelength measurements of a particular band series, known as the Herzberg bands, in oxygen show a distinct change in the electronic term, indicated by a change in the position of the band system for the electronic transition in the solid relative to that in the gas. Changes in vibrational frequencies and anharmonicities in the solid during such transitions appear to be relatively small and subject to some degree of uncertainty at present. Precise knowledge of these latter characteristics is limited by the width of spectra originating in the condensed phase.

Through these spectroscopic studies a large amount of information concerning free radicals at low temperatures has been obtained. However, many effects are left unexplained so that further comprehensive experimental studies are required. It is hoped that future research will provide a basis for an acceptable theory of the interactions that the emitting species undergoes with the solid or with neighbouring species, which will lead to a quantitative understanding of the properties and structure of solids containing free radicals.

Magnetohydrodynamic Low-Temperature Power Generation

TEN leading American power companies have joined with the Avco Corporation in a research project which could revolutionise the electric power industry and effect a 25 per cent increase in operating efficiency, due to the elimination of most of the turbo-generator in the conventional power generation cycle. The new power system is based on the scientific principles of magnetohydrodynamics (MHD). A small experimental laboratory device, utilising the MHD principle to generate electric power, is currently operating successfully at the Avco-Everett Research Laboratory in Everett, Massachusetts (Fig. 1). The utility group joining with Avco includes the Appalachian Power Company, Roanoke, Virginia ; the Central Illinois Light Company, Peoria, Illinois ; the Dayton Power and Light Company, Dayton, Ohio ; the Illinois Power Company, Decatur, Illinois ; the Indiana and Michigan Electric Company, Fort Wayne, Indiana ; the Indianapolis Power and Light Company, Indianapolis, Indiana ; the Kansas City Power and Light Company, Kansas City, Missouri ; the Louisville Gas and Electric Company, Louisville, Kentucky ; the Ohio Power Company, Canton, Ohio ; and the Union Electric Company, St. Louis, Missouri.

The project upon which the group has embarked will explore the feasibility of obtaining electric power from a "hot gas"—or magneto-hydrodynamic—generator. In a conventional electric power plant a solid coil of wire, or armature, cuts across a magnetic field to produce electricity. In the MHD generator a superheated, ionised gas is substituted for the armature, eliminating much of the heavy and costly equipment of a conventional system. Magneto-hydrodynamic studies have been conducted for more than ten years by the Avco-Everett Research Laboratory. The Avco staff first began work in the MHD field in connection with space propulsion and the many problems involved in successful re-entry from outer space. As the result of these investigations of space travel and re-entry, sufficient knowledge of the behaviour of high-temperature gases has been acquired to make possible a serious attempt to produce electrical power commercially.

The MHD Principle

Magnetohydrodynamics is the study of the interactions between a magnetic field and a hot, ionised gas. At high enough temperatures, gases become ionised (that is the atoms comprising the gas tend to lose one or more of the electrons which circle the atomic nucleus). A normal atom is electrically neutral—the negative charges of the planetary electrons are balanced by the positive charges of the protons in the nucleus. When electrons are lost, the atom becomes a positively-charged ion. The free electrons, naturally, maintain their negative charges. An ionised gas will conduct electricity and, when passing through a magnetic field, will generate electricity. In the experimental laboratory device shown in Fig. 1, the Avco Everett Research Laboratory has recently attained a 10kW power output. This achievement constitutes a first step in putting experimental theory into engineering practice.

Preliminary theoretical investigations have shown that an MHD power plant could give greater efficiencies at a competitive capital cost with conventional plants. Some experimentation has been completed which corroborates the theoretical findings. The basic problem of the MHD generator is heat. To yield electrical power, the gas in the generator must be at a very high temperature—above 4000 deg. Fah.—creating structural problems. Materials exist which have satisfactorily handled comparable temperatures, but never under the conditions of the MHD system. The highest temperature dealt with in the present research study will be approximately 5300 deg. Fah. The American Electric Power Service Corporation and the Avco-Everett Research Laboratory have studied two power cycles in which MHD generators can be used : one, a coal-burning open-cycle plant; the other, a closed-cycle, nuclear system

Open-Cycle, Coal-Fired MHD Power Plant

This design is conceptually similar to a conventional gas turbine–steam turbine combination : the MHD generator replaces the gas turbine. The plant is scaled to deliver 450MW, with the MHD generator producing more than three-fourths of net total power directly and providing the heat for the steam turbine sub-system. In this system, coal is added to preheated air and burned to obtain very high furnace temperatures. The furnace gases, seeded with 0·1 per cent potassium to increase conductivity, then pass through the MHD generator, where a large amount of heat energy is converted directly into electrical power. The remaining heat energy is used to produce electricity in a conventional steam cycle. The MHD generator itself should be mechanically simple and reliable and can be built to relatively low tolerances and at low cost. The biggest problem will be the heat and chemical reaction between the coal combustion products and the structural materials in other components of the cycle. A rule-of-thumb cost estimate, based entirely on the capital costs of equipment in the MHD system that will replace equipment in the conventional system, indicated that there are only minor differences between the two. This estimate did not include costs that would be common to both systems and it did not reflect the smaller size and higher efficiency of the MHD power plant. Estimates indicate that a heat rate of 6200 B.Th.U. per kWh, or 55 per cent thermal efficiency, could be obtained. Assuming that the capital costs are roughly the same, the relative fuel cost would be only 0·178 cent per kWh.

Closed-Cycle, Nuclear-Fuelled MHD Power Plant

At the present state of the art, it is very difficult to obtain nuclear reactor temperatures as high as furnace temperatures. However, other factors can compensate for this. The most immediate design advantage of the nuclear-fuelled MHD system is that it can use an inert working fluid : helium or argon, with 1 per cent cesium "seeding." This not only means that the working fluid will have a better conductivity—it greatly reduces the problems of chemical reaction with the structural materials, which was a consistent difficulty in the coal-cycle MHD system. With conductivity improved, the system can operate at lower temperatures. A heat rate of 5800 B.Th.U. per kWh is possible, better than that of the coal-cycle MHD. The nuclear MHD system assumes that a nuclear reactor capable of operation at high temperatures will be available in the foreseeable future. Recent developments in the Project Rover reactor design effort have shown that such an assumption is not unwarranted. The nuclear-cycle MHD system is again proportioned to deliver 450MW. The MHD generator is of the same size and field strength as in the coal cycle. The cycle is, then, similar to the coal-fired cycle, with the major exception that a nuclear reactor replaces the coal furnace. The materials problem is reduced in the nuclear cycle because of the lower operating temperatures

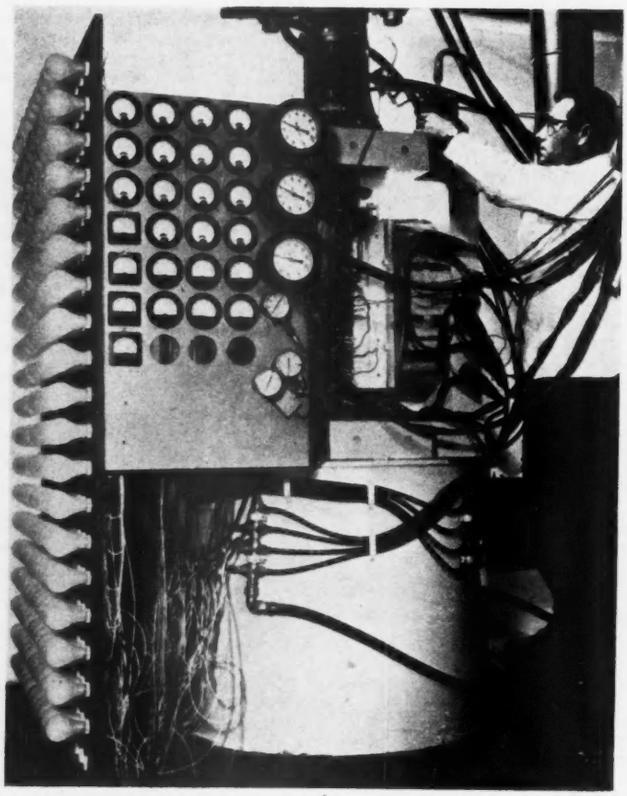


Fig. 1—10kW experimental MHD power generator with gas being heated and ionised by an electric arc at the top and passing downward through a magnetic field where electric current is induced and tapped off through electrodes

and the inert working fluid. No cost estimates have been made for the nuclear-cycle MHD generator, but its simplicity and efficiency look promising.

Development of MHD

Generating electric energy by the magneto-hydrodynamic principle is not a new idea. Patents dealing with the idea of producing electric energy without moving parts by the motion of a conducting fluid (in one case, salt water) through a magnetic field are available and date back at least fifty years. But the various forms of the idea previously visualised never got very far because of inadequate understanding of the phenomenon involved. There was a lack of knowledge of the performance of gases at high temperature. Recent work, however, in the study of missile re-entry problems has developed a good theoretical understanding of the electrical conductivity characteristics of gases at high temperatures in ranges above those normally encountered in thermal-power plants. This new understanding raised the question of whether or not a technically feasible and economically attractive plant for the large-scale generation of electric energy can be built, using MHD principles. For more than three years, operating under U.S. Air Force contract, the Avco-Everett Research Laboratory has been investigating the behaviour of high-temperature gases in shock tubes and correlating the results with modern theoretical physics and aerodynamics. This work led to re-examining various aspects of generating electric energy utilising MHD concepts. Avco-Everett has proposed that electric energy could be generated by passing a high-temperature high-velocity gas stream through a strong magnetic field. To obtain adequate gas conductivity the machine must operate at high temperatures. These present handling problems but promise high thermal efficiencies in a device that acts like a gas turbine but is completely static and yields electric power directly.

To obtain an estimate of the fuel and capital cost which might be needed by a coal-burning MHD plant, a specific preliminary design has been made. An open cycle was chosen in preference to a closed cycle because of its greater simplicity. This selection reduces problems of multiple heat transfer even though leading to more difficult problems in the MHD generator and associated equipment because of passing the products of combustion directly through the generator. In making this preliminary design, knowledge and experience gained in studying the re-entry problem of intermediate-range and intercontinental ballistic missiles was the prime guide in putting quantitative values on such unknowns as disassociation at high temperatures, particularly of the coal combustion products, heat-transfer rates at these extremely high temperatures and the effect of additive seeding agents. All these factors must be checked by test before an actual plant layout could be designed or even before effective final design of cycle arrangement could be made.

Fig. 2 shows the preliminary coal-burning MHD cycle. The MHD generator is combined with a conventional reheat steam turbine to obtain a highly efficient cycle. The cycle performs like a combination steam turbine–gas turbine cycle in which the MHD generator takes the place of the high-temperature gas turbine. By virtue of the high operating temperatures, a low heat rate of about 6200 B.Th.U. per kWh is indicated, constituting a 25 per cent improvement on the heat rate of the most efficient plants now projected. This would be subject to improvement as experience was gained with the operation of this type of equipment.

The preliminary study work is by no means adequate to define fully the best operating conditions for peak efficiency, but the diagram shows reasonable values. Flow rates have been chosen to give a net plant output of about 450MW. In practically all respects the MHD generator is more attractive in larger sizes. The cycle compresses atmospheric air to about 140 lb per square inch absolute and heats it to 3600 deg. Fah. in a regenerative air heater. Coal combustion raises the gas to 5300 deg. Fah. The conductivity of this high-temperature gas is increased where necessary by " seeding," i.e. by adding a small amount of vaporised metal, such as potassium. The gas then passes through the MHD generator, where it develops about 360MW of d.c. energy. Hot exhaust gas from the MHD generator at 4200 deg. Fah. passes through the regenerative heaters, cools to 2100 deg. Fah. and then flows to the boiler. Steam generated in cooling the gases from 2100 deg. Fah. to 300 deg. Fah. drives a conventional steam turbine that supplies power for the compressor and generates an additional 107MW of a.c. energy.

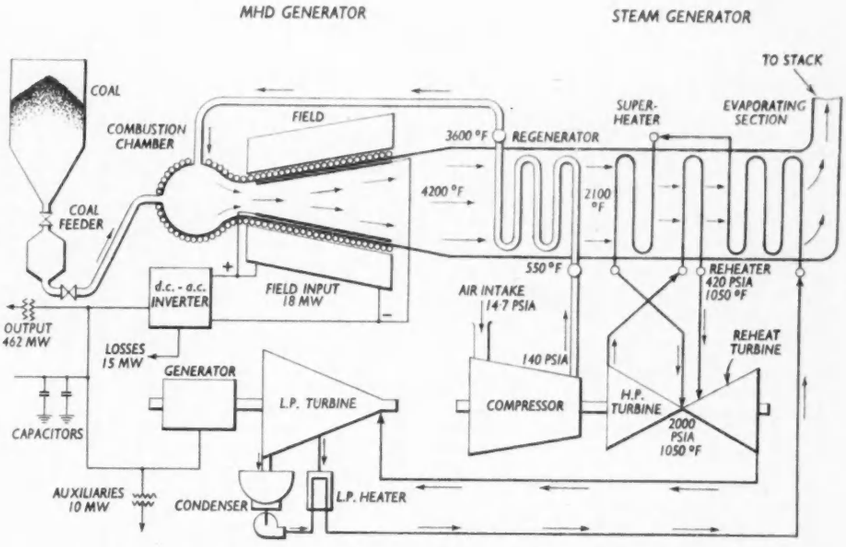


Fig. 2—Proposed flow diagram for an open-cycle coal-fired MHD power plant

In this cycle the steam turbines, boiler, compressors, a.c. generator, feed-water heaters and their auxiliaries, are essentially conventional equipment and represent no problem in development. The MHD equipment, however, represents special problems which would require research and development effort, particularly on the behaviour of high-temperature gases in magnetic fields and on high-temperature materials.

It is much too early to prepare a reliable study of the economics of electrical energy generation by an MHD generator. Many of the fundamental principles need to be more thoroughly investigated and established. Yet a start has been made on sketching in the economic parameters. More particularly, since the successful development of an MHD generator would displace certain heretofore indispensable items of cost in conventional plants, one can put together a table of costs that might be eliminated and new costs incurred. The MHD generator displaces heat-absorbing parts of the boiler, such as steam generating, superheating and reheating, and also steam piping, the steam turbine, the turbo-alternator, the steam condenser, the boiler-feed pumps and a host of additional associated equipment. The following table shows a preliminary comparison of major equipment that would be different for the two units :

Comparison of Investment Costs, Conventional Versus MHD Generating Units

Equipment	Conventional unit, dollars per kilowatt	M.H.D. unit, dollars per kilowatt
1. Steam generator and accessories	31	10
2. Steam turbo-generator and compressor drive	38	12
3. Air compressors	—	4
4. Regenerator	—	7
5. M.H.D. generator	—	7
6. High-temperature valves, ductwork and combustion chamber	—	4
7. Electrical converters and accessories	—	33
8. Reactive supply	—	5
9. Piping, pumps, heaters and condensers	23	10
10. Building space for conversion equipment	—	—
	92	94

These costs are mainly based on experience, with the exception in the case of the MHD unit of items 4, 5, 6 and 7. In a great many areas the MHD unit has great economic advantages over the conventional one but it has a principal handicap in the fact that at the present time generation of direct current seems more feasible than the generation of alternating current. This requires for all practical applications the conversion of direct current to alternating current. It appears that this conversion can be done at a capital cost of 40 dollars per kilowatt and at an efficiency of approximately 96 per cent.

It is certain that formidable problems must be faced before an MHD plant like this can be designed and operated. These problems consist mainly of understanding the stability of current paths in the gas, electrode effects and other MHD phenomena. In addition, materials must be developed to handle gases at the very high temperatures which would be encountered in a magnetohydrodynamic plant.

The preliminary investigations carried out in the study recently completed indicated that there is fair expectation that the theoretical and practical problems can be solved. Before accepting this tentative conclusion, however, it was felt that a programme of work involving a number of stages ought to be carried out. Essentially this would consist of the following :

(1) A study of the basic principles of electrical energy generation by a hot conducting gas stream interacting with a magnetic field : (*a*) construction and operation of experimental generators ; (*b*) theoretical study of types of generator.

(2) A search for and development of high-temperature materials suitable for use in an MHD generator and in the heat sources and heat exchangers associated with it : (*a*) tests of heat exchanger, liner and electrode materials ; (*b*) design of heat exchanger and electrode configurations.

(3) A study of electrical conductivity in gases : (*a*) a search for superior seed materials ; (*b*) refinement of present values for collision cross sections in gases of interest.

(4) Engineering and economic studies of overall power plant design.

The completion of this programme should determine the practical validity of the basic theory on which the MHD generator is based, as well as develop general solutions for the critical materials problem. If this first stage were concluded satisfactorily, it might open the way to the projection of a smaller prototype plant which, in turn, would have to carry with it a research and development phase, the successful completion of which would lead to the building of a demonstration prototype plant.

Personal and Business

Appointments

MR. R. H. VIVIAN, A.M.I.E.E., has joined Wireless Telephone Company, Ltd., as chief engineer.

MR. A. H. SIMPSON has been appointed commercial manager of Woodfield Rochester, Ltd.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has appointed Mr. Stanley White as its chief press officer.

MR. P. RANSOM has joined International Rectifier Company (Great Britain), Ltd., as engineering manager.

THE JOHN THOMPSON CONVEYOR COMPANY, has appointed Mr. P. D. Hunter to be its London and southern area sales engineer.

MR. JOHN HAY, joint parliamentary secretary to the Ministry of Transport, has appointed Mr. Ernest Partridge, M.P., as his parliamentary private secretary.

MR. D. N. STEELY has been appointed sales manager of standard industrial motors at The General Electric Company, Ltd., Engineering Works, Birmingham.

SHEEPBRIDGE STOKES, Ltd., has announced the appointment of Mr. J. C. Morton as its technical representative in the north and east area from Lincolnshire to the Scottish border.

THE SOUTH STAFFORDSHIRE WATERWORKS COMPANY announces that, due to the retirement of Mr. R. A. Robertson, M.I.C.E., Mr. R. H. Taylor, M.I.C.E., has been appointed engineer-in-chief as from January 1, 1960.

MR. A. W. CLARK, M.I.Mech.E., has been elected president of the Glass Manufacturers' Federation in succession to Mr. L. T. Sawney. Mr. I. B. Throndsen has been elected chairman of the council and Mr. I. M. Bailey, vice-chairman.

DR. GEORGE MACFARLANE has been appointed deputy director of the National Physical Laboratory. He succeeds Dr. Edward Lee, who will take up new duties on January 1, as director of stations and industry divisions at the Department of Scientific and Industrial Research headquarters.

THE INCANDESCENT HEAT COMPANY, Ltd., announces that it has seconded Mr. B. A. Harper to the staff of A.B.M.T.M. (India), Ltd., where his post will be that of senior furnace technician (India). A.B.M.T.M. (India), Ltd., has represented The Incandescent Heat Company, Ltd., in India for almost fifty years.

EDGAR ALLEN AND CO., Ltd., has announced the reconstitution of the boards of directors of four subsidiary companies in the United Kingdom. They are as follows: British "Rema" Manufacturing Company, Ltd.: Brigadier A. Levesley, Mr. W. J. McBride, Mr. J. P. Lewis, Mr. W. G. A. Jenkins, Mr. J. Higginbotham; Buell (1952), Ltd.: Mr. W. J. McBride, Brigadier A. Levesley, Mr. O. Margetson, Mr. G. B. Tyler, Mr. M. G. Hill, Mr. F. A. Ross; J. H. Humphreys and Sons, Ltd.: Brigadier A. Levesley, Dr. E. Gregory, Mr. A. Humphreys, Mr. G. W. Turton, Mr. F. Haigh, Mr. W. C. Garrison; Park View Steel Works, Ltd.: Dr. E. Gregory, Mr. A. H. Baxter, Mr. F. Haigh, Mr. G. C. Longden, Mr. W. H. Everard, Mr. L. F. Keeley. Mr. F. A. Ross will retain the secretaryship of each of these companies, with the exception of Buell (1952), Ltd., where Mr. D. F. Tiplady has been appointed secretary. Edgar Allen and Co., Ltd., also announces that Mr. F. Haigh has been appointed deputy general sales manager of the parent company; Mr. L. F. Keeley (general manager) and Mr. R. E. Sherwood (deputy general manager), of the steel department, and Mr. R. Gabbertas, head of the operational research department.

Business Announcements

DE LA RUE BULL MACHINES, Ltd., has opened a showroom and computer centre at 114-118, Southampton Row, London, W.C.1.

PRODUCTION-ENGINEERING SOCIETE ANONYME, 3, Square de l'Opera, Paris IXeme, has been created as a member of the Production-Engineering Group of Companies.

MR. SAM BLACK, head of the publicity department of the British Electrical and Allied Manufacturers' Association is resigning his post at the end of this year to take up a new position in publishing.

ELECTRO METHODS, Ltd., states that its electrical connector division has moved to new premises at Hitchin Street, Biggleswade, Beds (telephone Biggleswade 2086). The divisional manager is Mr. D. P. Wright.

THAMES PLYWOOD MANUFACTURERS, Ltd., Harts Lane, Barking, Essex, states that production of its moulded goods has been transferred to the Coventry Timber Bending Company, Ltd., Torrington Avenue, Coventry.

POWELL DUFFRYN, Ltd., announces that Powell Duffryn Engineering Company, Ltd., has acquired the whole of the share capital of Pipeweld, Ltd., which operates from Paston Road, Wythenshawe, Manchester, 22.

THE HAWKER SIDDELEY GROUP and MITCHELL COTTS GROUP announce the opening of a new workshop in Tripoli. The workshop has been equipped to meet the increasing demands of oil well operators and provision has also been made for servicing agricultural and power generating equipment.

JENKS BROTHERS, Ltd., Britool Works, Bushbury, Wolverhampton, states that, with its subsidiary, The British Tool and Engineering Company, Ltd., it has operated at the same establishment for many years and it has now been decided that the latter should carry on the trade of both companies, and as from January 1, 1960, be renamed Britool, Ltd.

JAGUAR CARS, Ltd., Coventry, has announced that arrangements have been made between its subsidiary, Jaguar Cars Inc., and Leyland Motors, Ltd., for the marketing in the U.S.A. of commercial vehicles manufactured by the latter company. This has been put into effect by the formation of a new company, Leyland Motors (U.S.A.), Inc., as a subsidiary of Jaguar Cars Inc. President of the new company is Mr. Johannes Eerdmans, who is also the president of Jaguar Cars Inc.

BABCOCK AND WILCOX, Ltd., announces that arrangements have been made for the company to manufacture in Great Britain, under licence from Ets. Richier S.A., vibratory road-rollers and reversing-drum concrete mixers. Similar licence arrangements have been made with Jules-Weitz C.A.C.L. for the manufacture under the name of Babcock-Weitz, of Weitz tower cranes. These machines will continue to be distributed, in Great Britain, by Machinery (Continental), Ltd., 42, Park Street, London, W.1.

TUBE INVESTMENTS, Ltd., announces that its subsidiary, the Chesterfield Tube Company, Ltd., has reached an agreement with the Superior Tube Company of Norristown, U.S.A., on the manufacture of beryllium. As a result of the agreement, the Superior Tube Company will be supplied with the techniques of beryllium tube drawing and finishing developed by the Chesterfield Tube Company and T.I. Research and Development Division. The future beryllium research programmes of the two companies will be co-ordinated with a full exchange of information.

Contracts

JOHN DALGLISH AND SONS, Ltd., has received a contract from Russia worth over £500,000. The contract is for the manufacture, supply and erection of a series of machines for dewatering, drying, baling, wrapping and packaging of synthetic rubber. The fully-integrated plant will have an annual output of 70,000 tons.

ASHMORE, BENSON, PEASE AND CO., Ltd. (member of the Power-Gas Group), Stockton-on-Tees, has received a contract valued at approximately £4,000,000 for the design, manufacture and erection of two complete blast furnaces for Richard Thomas and Baldwins, Ltd. The two furnaces will each have a hearth diameter of 30ft and will be installed at Spencer Works, near Newport, Monmouthshire.

P.G. ENGINEERING, Ltd., (a member of the Power-Gas Group), has agreed a contract with V/O Techmashimport, Moscow, for the complete supply of a plant for the production of polystyrene with rated capacity of 5000 tons a year. The value of the complete plant is approximately £650,000, and delivery is scheduled to begin next year. The process design is to be supplied by BX Plastics, Ltd., and P.G. Engineering, Ltd., will be responsible for the engineering and supply of equipment.

FERRANTI, Ltd., has received an order worth about £280,000 from the AB Turitz and Co. of Gothenburg, Sweden, for the first "Orion" high-speed data-processing system to go on the new production line at the manufacturer's West Gorton Works, Manchester. Turitz and Co. who operate the largest chain of multiple stores in Sweden as well as several large independent stores, will make use of "Orion" for data-processing and stock control. It is expected that it will be installed about the end of 1961. The system will be fitted with punched cards, magnetic tape and high-speed printers. It will be equipped with thirty keyboards installed in the central buying department of the company's headquarters in Gothenburg. These keyboards will be operated by buyers to obtain immediate information on stock levels throughout the network of fifty-two chain stores. The computer's time-sharing facilities enable the keyboards to be operated continuously, even though the computer itself is engaged on other data-processing work. If the computer is engaged, requests from the keyboards are stored by a system of priority processing and automatically answered when parts of the computer become available.

AUSTRALIAN ELECTRICAL INDUSTRIES (PTY.), Ltd., acting on behalf of Associated Electrical Industries Export, Ltd., has received an order for the supply of two 200MW steam turbine-generator sets and associated equipment for the new Hazelwood power station to be built in the Latrobe Valley area of Grippsland, about 90 miles east of Melbourne. The power station will have an ultimate capacity of 1200MW, and the 400MW of A.E.I. plant will form the first stage of the project. The contract (worth about £3,600,000) also includes condensers and feed-water heating plant, boiler feed pumps and make-up water plant, cranes and miscellaneous turbine house equipment. The turbine-generator sets will be made at A.E.I. Trafford Park Works; the principal items of heat exchange equipment, including the condensers, will be made in Australia to A.E.I. designs. The turbines will be three cylinder tandem-compound impulse, 3000 r.p.m. machines. Steam will be received at 1500 lb per square inch gauge, 1050 deg. Fah. via two steam chests, one of which will carry two combined isolating and emergency stop valves, and the other two governor valves. Double shell construction will be used for the high-pressure cylinder casing, and an intermediate pressure section will be followed by three low-pressure flows, each incorporating a Baumann multi-stage exhaust. The high-pressure rotor, the combined intermediate-pressure/single-flow low-pressure rotor, and the double-flow low-pressure rotor, will each be machined from monobloc forgings with integral discs. They will be solid-coupled and carried by spherically-seated white-metalled journal bearings. A Michell thrust bearing will be housed within the pedestal between the high-pressure and intermediate-pressure rotors. Steam will exhaust to a twin-shell condenser at a vacuum of 28in Hg., with a cooling water supply of 72,000 g.p.m., 69 deg. Fah. Bled steam from the turbine will supply two low-pressure heaters, a deaerator and two high-pressure heaters, giving a final feed water temperature of 420 deg. Fah. from the five-stage system. Cooling of the 15kV, 3000 r.p.m., generator stator windings will be by water circulating in direct contact with the copper. Rotor cooling will be by forced circulation of hydrogen. Generator exciters will be gear-driven from the generator shaft.

Miscellanea

NATIONAL BOAT SHOW.—The sixth Annual Boat Show sponsored by the *Daily Express* and organised by the Ship and Boat Builders' National Federation will be held at Earls Court, London, and will open on Wednesday, December 30 and close on Saturday, January 9, 1960. Over 300 craft will be on display, including the "Hovercraft."

MOBILE CRANE.—The 10 tons capacity "Jones KL 10-10" mobile crane produced by K. and L. Steelfounders and Engineers, Ltd., Letchworth, Herts, is to be replaced by a modified machine having a 12½-ton capacity at 10ft radius. In this crane the original conventional cab which occupied the full width of the chassis has been replaced by a "fore and aft" cab offset on the off side. Two driving positions are provided, one facing forwards, for road travel, and one facing the rear, the latter being equipped with simplified "fingertip" crane controls together with duplicate travel controls arranged as in standard automotive practice.

COASTAL RADIO V.H.F. SERVICES.—A new Post Office coastal radio v.h.f. telephony service for shipping was introduced at the Humber (Mablethorpe) coast radio station on December 1, and will be followed by a similar service opening at the Land's End station early in January, 1960. The two services will serve the important sea areas and shipping lanes within about 40-50 miles of the stations. Charges for a three minute call will be 6s. 6d. for the combined coast station and ship charge, plus a landline charge of 6d. or 2s. 6d., depending on the distance between the coast station and the telephone subscriber inland. Each station will operate on two traffic channels. Similar v.h.f. services have already been provided on the Clyde and at North Foreland (see our November 20 issue) and Niton (I.o.W.).

British Patent Specifications

When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

COAL CARBONISATION

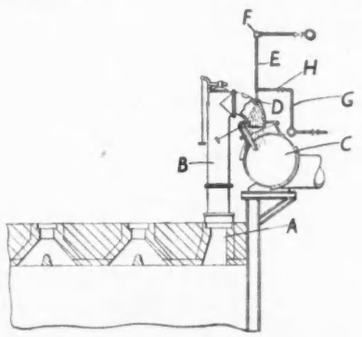
823,530. November 23, 1956.—CARBONISATION OF COAL, Frederick Joseph West, Knight, and Ernest West and West's Gas Improvement Company, Ltd., all of Albion Ironworks, Miles Platting, Manchester, 10.

In a plant in accordance with this invention, there may be three separate retorts. The cycle in each retort may consist of: (1) charging the retort with coal and applying internal heat to carbonise the coal to semi-coke; (2) heating the semi-coke to produce coke; (3) cooling the coke and discharging it. During the coke cooling stage, gases from the first retort may be passed through a second retort containing semi-coke to be turned into coke and thence the gases may be passed through a third retort containing coal to be converted into semi-coke. Also blue water or carrier gas may be passed through the chamber containing the coke being cooled. Gas obtained from a retort containing coal which is being carbonised may be heated and passed through a chamber containing semi-coke being carbonised to coke. An exhauster may be used to circulate such gas, part of which may go to the plant gas off-take. If desired, the number of retorts and the number of stages in a complete cycle may be increased. Thus, there may be four retorts and four stages in each retort. In stage I, coal may be carbonised to low temperature coke. In stage 2 low temperature coke may be carbonised to semi-coke. In stage 3 semi-coke may be carbonised to high temperature coke, and in stage 4 the coke may be cooled prior to discharge. Drawings accompanying the specification show diagrammatically a carbonisation plant in which the carbonisation process is carried out in three stages.—*November* 11, 1959.

COKE OVENS

823,589. July 10, 1957.—AN ARRANGEMENT FOR DRAWING OFF THE CHARGING GASES FROM A COKING CHAMBER OVEN, Heinrich Koppers Gesellschaft Mit Beschrankter Haftung, Moltkestrasse 29, Essen, Germany.

In accordance with this invention, the nozzle used for the spraying of liquor during the coking process is used simply as an injector for drawing off the charging gases during the charging of the oven chamber, by shutting off the flushing liquor supply and by opening the gas or steam supply. When the charging is completed, the gas or steam supply is again cut off and the supply of flushing liquor restored so that the nozzle is in constant use, either for the passage of flushing liquor or of gas or steam. Thus, the use of two nozzles, on the one hand for the liquor supply and on the other for the gas or steam supply, or the use of a complicated combined nozzle, is avoided. A preferred embodiment of the invention is illustrated in the accompanying drawing. At one end of the top of an oven chamber is the gas withdrawal opening *A* connected to which is an



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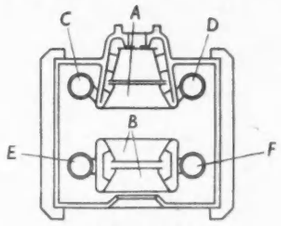
ascension pipe *B*, at the top of which is a bend leading to the main *C*. A spray nozzle *D* in the bend, directed into the main, is connected to a flushing liquor conduit *E* which has a branch in which is a non-return valve *F*. Connected at the lower part to the conduit, just in advance of the spray nozzle, is a gas admission line *G* through which distillation gas is supplied from a distributor pipe, for example, at a pressure of 5 atmospheres. A valve *H* is arranged in the admission conduit. The non-return valve *F* in the flushing liquor conduit is closed by opening the valve *H* so that, during the charging of the oven chamber, the charging gas developed is drawn off through the ascension pipe *B* and into the main *C*. After the valve *H* has been closed, the non-return valve *F* opens and the flushing liquor, at an approximate pressure of 1·5 atmospheres, passes through the spray nozzle and into the main.—*November* 11, 1959.

STEAM TURBINES

823,267. September 27, 1956.—STEAM TURBINE SET WITH BLEEDER STEAM FEED WATER PREHEATER, Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland.

Feed water preheaters which are heated with bleeder steam from the turbine have hitherto generally been separate from the turbine and connected to the bleeding points by more or less long pipes. The present invention consists in a steam turbine set with a low-pressure casing and with at least one feed water preheater arranged vertically in the interior of the low-pressure casing. In the form illustrated, a low-pressure casing contains the inner casings *A* and



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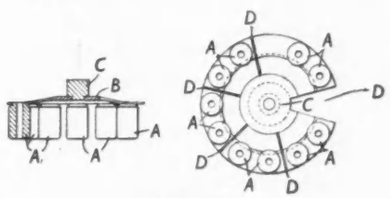
B of the triple-flow low-pressure cylinder of the turbine as well as low-pressure feed water preheaters *C*, *D* and *E*, *F*, connected to the last two bleeder steam extraction stages of the turbine. Preheaters *C*, *D* are connected to the penultimate pressure stage and preheaters *E*, *F* to the lowest pressure stage. The bleeder connections are short and there is no need to provide tight connections because these, as well as the preheaters, are completely in vacuum. In order to reduce the volume of a single preheater, it is an advantage to divide it for a certain pressure stage into two parts with corresponding bleeder pipe lines; the space required inside the turbine casing is thus diminished. Furthermore, if tube defects occur in one of the part preheaters, it can be shut off from the feed water supply and the turbine does not need to be stopped, and in such a case the whole feed water will flow through the other part.—*November* 11, 1959.

ELECTRONICS

822,766. April 26, 1957.—MAGNETRONS, English Electric Valve Company, Ltd., Queens House, Kingsway, London, W.C.2. (*Inventors: Maurice Esterson and Alec Peter Orme Collis.*)

This invention relates to multiple resonant cavity tunable magnetrons in which tuning is accomplished by means of conductive pins carried upon an adjustable conductive carrier member and which project into the resonant cavities. In magnetrons of this kind experiment has shown that objectionable spurious resonances occur due to voltages which are induced



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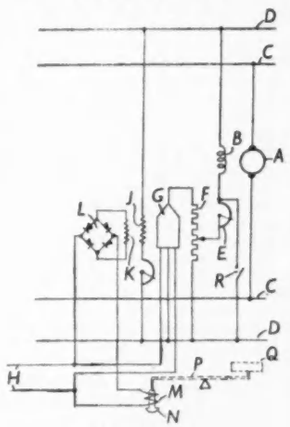
in the tuner pins, causing currents to flow axially along the pins and around the carrier disc by which they are supported. These resonances are very dependent on small displacements of the entire pin and carrier assembly, for example on small rotations about the axis. According to this invention, the tuning pin carrier disc of a multiple resonant cavity tunable magnetron is radially slotted only between successive pairs of tuning pins (counting round the carrier) so that successive pairs of pins are divided off from one another by a slot. Referring to the drawings, the tuning assembly comprises a ring of metal tuner pins *A* mounted on and at right angles to a metal carrier disc *B* provided with a lead screw member or nut *C*. Slots *D* extending radially of the carrier member *B* are provided with each slot being between successive pairs of tuning pins counting round the carrier, so that each pair of pins is between two slots. In the particular construction shown, one of the radial slots is made much wider than the others and the pins do not occur at regular intervals all round the carrier member, but these characteristics are associated only with a particular magnetron and have nothing to do with the invention.—*October* 28, 1959.

ELECTRICAL ENGINEERING

822,743. September 17, 1956.—AUTOMATIC CONTROL OF THE DELIVERY OF CONVEYORS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventors: Raymond Georges Rayden and Donald Windsor Prowse.*)

In many cases it is desirable to control a mechanical feeding movement. For instance, it may be necessary to control the weight of material moved per unit of time by a conveyor. This can be done by controlling the operation of an electric motor driving a turntable or a second conveyor feeding the first conveyor in dependence upon the positional displacement of a member of a weighing equipment associated with the first conveyor. According to this invention, an electric motor, driving a feeder, such as a conveyor, supplying the material to the conveyor (not shown) whose output is to be controlled, has its armature *A* and field winding *B* connected to supply sources *C*, *D* respectively. A controlling voltage for the field winding is additionally supplied through a potentiometer *E* from a load resistor *F* of a magnetic amplifier *G*, such as a "Magnestat," which draws power from an a.c. supply source *H*. Bias winding *J* is connected to the d.c. supply *D*, and a control winding *K* is connected through a rectifier bridge *L* to a control inductor or reactor winding *M*, a movable core *N* of which is mechanically interconnected with the beam *P* of a weighing equipment *Q* to follow posi-



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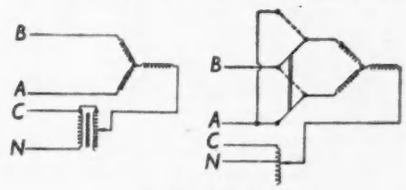
tional changes of the beam in accordance with weight variations. Such an arrangement makes it possible to control the motor operation in accordance with the movements of the beam so as to eliminate these movements, and control signals varying with the movements of a weighing member are obtained without similar movements of a contact member in the control circuit. A switch *R* by-passing the output of the magnetic amplifier is provided to render this additional control voltage ineffective at periods when it is not required, for instance, when starting a conveyor plant. The provision of potentiometer *E* also permits an increase in the accuracy of the control by presetting this potentiometer to regulate over a range corresponding to the maximum error expected without the additional control according to the invention.—*October* 28, 1959.

822,513. February 15, 1957.—CONTROL SYSTEMS FOR INDUCTION MOTORS, Brush Electrical Engineering Company, Ltd., Falcon Works, Loughborough, Leicestershire. (*Inventor: Denis Raymond Hardy.*)

Various methods of controlling the speed of a polyphase induction motor running on a constant-frequency supply are reviewed in the introductory



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paragraphs of this specification, among them being the control of the symmetrical three-phase voltage components applied to the magnetising winding of the motor. The object of this invention is to provide

improved or simplified means of varying these symmetrically applied voltage components, called the positive sequence components and, in addition, to supply the motor with symmetrical voltage components of negative-sequence, the two systems of symmetrical voltage components having a definite relationship to each other. Control of the positive and negative sequence components fed to the motor will enable speed variation to be obtained from full speed forward to full speed reverse. Stability over this speed range is assured by suitable selection of the motor's torque-speed characteristic. Two methods of applying a variable voltage having the correct phase-relationship are shown in the drawings. In the left-hand circuit the primary of a two-winding transformer having a primary/secondary turns ratio of 1 : 3 is connected between line *C* and neutral *N*, and the secondary is connected at one of a number of tappings to the motor terminal shown. Another method, shown in the right-hand drawing, is to connect one terminal of the motor to the secondary of an auto-transformer, which is designed to have a ratio of 1 : 1½ and is supplied from one line and neutral ; the other two terminals being connected to a two-pole reversing switch which is supplied from the other two lines. Selection of the ratio on the auto-transformer will vary the speed of the motor from full speed down to zero, and operation of the two-pole reversing switch will enable the auto-transformer to have the same control over the motor speed but in the reverse direction of rotation.—*October* 28, 1959.

Launches and Trial Trips

MALAISE, cargo ship ; built by Chantiers Navals de la Ciotat for the Messageries Maritimes ; length between perpendiculars 478ft 10in, breadth moulded 64ft 7in, depth to shelter deck 39ft 5in, draught loaded 26ft 2in, deadweight 9300 tons, displacement 15,000 tons, service speed 19·6 knots ; five holds, one 60-ton, one 30-ton, four 10-ton and ten 5-ton derricks, sixteen electric winches ; three 300kW diesel-driven generators ; one supercharged Sulzer diesel engine, ten cylinders, 760mm diameter by 1550mm stroke, 13,450 h.p. at 120 r.p.m. Trial, August.

TIDRA, cargo ship ; built by the Forges et Chantiers de la Mediterranée (La Seyne) for the Compagnie Maritime des Chargeurs Réunis ; length between perpendiculars 433ft 7in, breadth moulded 61ft, draught 24ft 2in, deadweight 8000 tons, service speed 16 knots ; five holds, one 20-ton, six 8-ton and ten 5-ton derricks, electric winches, two 240kW diesel-driven generators, and one 100kW shaft-driven generator ; Sulzer Mark 9S.D.72 diesel engine, 6300 h.p. Trial, August.

ILORIN PALM, cargo liner ; built at the Neptune works of Swan, Hunter and Wigham Richardson, Ltd., for the Palm Line, Ltd.; length between perpendiculars 430ft, breadth moulded 62ft 6in, depth moulded to shelter deck 36ft 11in, deadweight 8550 tons on 25ft 0¼in draught ; five cargo holds, three bipod masts, one 50-ton, four 15-ton, two 10-ton and ten 5-ton derricks, electric winches, two 100 tons per hour oil cargo pumps ; three 250kW diesel-driven generators ; Swan Hunter-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4500 b.h.p. at 118 r.p.m. Launch, September 2.

SAN CONRADO, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for the Eagle Tanker Company, Ltd.; length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in, deadweight 31,725 tons on 34ft 2½in Lloyd's Summer draught, designed speed 15¼ knots ; ten treble cargo oil tanks, one main cargo pump room, four 900 tons per hour centrifugal turbine-driven, cargo pumps, four 150 tons per hour stripping pumps ; two 600kW, 450V, 60 c/s turbine-driven alternators, one 200kW diesel-driven alternator ; one set of Metropolitan-Vickers double-reduction geared turbines, 12,500 normal shaft horsepower at 105 propeller revolutions per minute, steam supplied at 600 lb per square inch and 850 deg. Fah. by two Foster-Wheeler " D " boilers. Launch, September 17.

DEVON CITY, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., for Sir William Reardon Smith and Sons, Ltd.; length between perpendiculars 470ft, breadth moulded 67ft, depth moulded 40ft 8in, deadweight 14,450 tons on closed shelter deck draught ; five holds, one 25-ton and fourteen 5-ton derricks, electric winches, service speed 14¼ knots ; Doxford opposed-piston oil engine, five cylinders, 700mm diameter by 2320mm combined stroke. Launch, September 17.

TEESFIELD, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for Hunting (Eden) Tankers, Ltd.; length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, draught 30ft 6in, deadweight 18,025 tons, trial speed 15 knots ; twenty-seven cargo oil tanks, two cargo pump rooms, four 400 tons per hour horizontal cargo pumps, two 55 tons per hour stripping pumps, pipelines 10in bore ; one steam-driven and two diesel-driven 80kW generators ; Wallsend-Doxford opposed-piston, two-stroke oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 116 r.p.m., arranged to burn 3500 seconds fuel, two cylindrical multi-tubular boilers. Trial, September.

PINEBANK, cargo liner ; built at Belfast by Harland and Wolff, Ltd., for Andrew Weir and Co., Ltd.; length between perpendiculars 450ft, breadth moulded 62ft 6in, depth moulded to upper deck 38ft 6in, gross tonnage 6500 (open shelter deck), 8700 (closed shelter deck) ; two complete steel decks, five main holds, one 25-ton, two 10-ton, twelve 5-ton and two 3-ton derricks, fourteen electric cargo winches ; three 175kW diesel-driven generators ; Harland and Wolff, opposed piston, two-stroke, single-acting, diesel engine, six cylinders, 620mm by 1870mm combined stroke, 118 r.p.m. Trial, September 24.

IBADAN PALM, cargo liner ; built at the Neptune works of Swan, Hunter and Wigham Richardson, Ltd., for the Palm Line, Ltd.; length between perpendiculars 430ft, breadth moulded 62ft 6in, depth moulded to shelter deck 36ft 11in, deadweight 8950 tons on 25ft 1¾in maximum draught ; five cargo holds, three bipod masts, one 50-ton, four 15-ton, two 10-ton and ten 5-ton derricks, sixteen electric winches ; three 250kW diesel-driven generators ; Swan, Hunter-Doxford oil engine arranged to burn heavy fuel, four cylinders, 670mm diameter by 2320mm combined stroke, 4500 b.h.p. at 118 r.p.m. Trial, September 28.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ANTIQUARIAN HOROLOGICAL SOCIETY

Fri., Jan. 8.—Science Museum, Kensington, London, S.W.7, " Bells and Bellfounding," Douglas Hughes, 7 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Dec. 21.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, " The Clean Air Act in Operation," G. Hopper, 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Dec. 18.—SCOTTISH SECTION : Department of Natural Philosophy, The University, Drummond Street, Edinburgh, " The Digital Voltmeter," J. A. Irvine and D. A. Pucknell, 7 p.m.

Wed., Jan. 6.—RADAR GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, " Some New Possibilities in Civil Underwater Echo-ranging—Current Research at the University of Birmingham," D. G. Tucker, 6.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Mon., Dec. 21.—EAST ANGLIAN SECTION : Lecture Hall, Public Library, Ipswich, Film evening, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Wed., Jan. 6.—SWANSEA GROUP : Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, Chairman's Address, J. R. Smith, 6.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Wed., Dec. 30.—WEST MIDLANDS SECTION : Birmingham and Midland Institute, Paradise Street, Birmingham, " Energy from the Atom," C. F. Powell, 7 p.m.

INSTITUTE OF NAVIGATION

To-day, Dec. 18.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Film meeting, 5.15 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Jan. 7.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, " Some Lubricating Problems of Refrigerating Machines using Refrigerant 12," H. Heckmatt, 5.30 p.m.

INSTITUTE OF WELDING

Tues., Jan. 5.—CHRISTMAS LECTURE TO YOUNG PEOPLE : 54, Princes Gate, London, S.W.7, " The Magic Arc," Hugh O'Neill, 11 a.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Jan. 4.—WEST MIDLANDS CENTRE : Room No. 118, Gosta Green Technical College, Birmingham, " The Forage Harvester and Work Study in Relation to Silage Making and Feeding," F. S. Mitchell and N. W. Dilke, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Jan. 5.—Geological Society, Burlington House, London, W.1, " Heat Transfer to Two-Phase Gas/Liquid Systems—Part I," J. A. R. Bennett, J. G. Collier, H. R. C. Pratt and J. D. Thornton ; and " Pressure Drop and Hold-Up in Two-Phase Flow," J. G. Collier, J. D. Thornton and J. A. R. Bennett, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Wed., Jan. 6.—DUGALD CLERK LECTURE : Great George Street, Westminster, London, S.W.1, " Dredging Equipment," H. R. Cooper, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 4.—MERSEY AND NORTH WALES CENTRE : Donnan Laboratories, Vine Street, Liverpool, " Silicone Electrical Insulation," J. H. Davis, 6.30 p.m. ★ SOUTH MIDLAND CENTRE : James Watt Memorial Institute, Birmingham, Discussion on " Post-Graduate Academic Training Given within Industry," opened by R. F. Marshall, 6 p.m.

Tues., Jan. 5.—MEASUREMENT, SUPPLY AND UTILIZATION SECTIONS : Savoy Place, London, W.C.2, " A New Method for Observing the Phenomena of Commutation," H. J. H. Sketch, P. A. Shaw and R. J. K. Splatt ; and " A Method of Measuring Self-Inductances Applicable to Large Electrical Machines," J. C. Prescott and A. K. El-Kharashi, 5.30 p.m. ★ NORTH-WESTERN CENTRE : Engineers' Club, 17, Albert Square, Manchester, Second Hunter Memorial Lecture, " The Protection of Electrical Systems," H. G. Bell, 6.15 p.m.

Wed., Jan. 6.—SOUTHERN CENTRE : C.E.G.B. Offices, Portsmouth, " Non-Destructive Testing," E. McCabe, 6.30 p.m. ★ TEES-SIDE SUB-CENTRE : Cleveland Scientific and Technical Institution, Middlesbrough, North-Eastern Centre Chairman's Address, H. Watson-Jones, 6.30 p.m.

Thurs., Jan. 7.—ORDINARY MEETING : Savoy Place, London, W.C.2 Second Hunter Memorial Lecture " The Protection of Electrical Systems," H. G. Bell, 5.30 p.m. ★ WESTERN CENTRE : Technical College, Swindon, Joint meeting with the Western Branch of the Institution of Mechanical Engineers, " The ' Deltic ' Locomotive," C. M. Cock, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., Jan. 6.—MIDLANDS BRANCH : Queens Hotel, Birmingham, " Measuring and Gauging Equipment," T. Ellerby, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., Dec. 21.—SCOTTISH A.D. CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, " Construction and Behaviour Characteristics of Tyres," T. French, 7.30 p.m.

Tues., Dec. 22.—LONDON GRADUATES' SECTION : 1, Birdcage Walk, London, S.W.1, Film Evening, 6.30 p.m.

Mon., Jan. 4.—NORTH EASTERN BRANCH : Neville Hall, Newcastle upon Tyne, " Atomic Energy Factories : Design and Construction Problems," H. V. Disney, to be read by H. Norris, 6 p.m.

Wed., Jan. 6.—EAST MIDLANDS BRANCH : College of Further Education, Loughborough, Annual Meeting ; and " Design by Analogy," J. O'N. Fisher, 7 p.m.

Thurs., Jan. 7.—EASTERN BRANCH : Argyle Works, Stevenage, Chairman's Address, " Mechanical Seals," R. G. Allen, 7.30 p.m. ★ EAST MIDLANDS GRADUATES' SECTION : Gas Showrooms, Peterborough, " Some Aspects of Machine Tool Design for the Future," F. A. Lewis, 7.15 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Jan. 7.—10, Upper Belgrave Street, London, S.W.1, " The ' Brave ' Class Gas-Turbine Fast Patrol Boats," J. T. Revans and A. A. C. Gentry, 4.45 p.m.

INSTITUTION OF PLANT ENGINEERS

To-day, Dec. 18.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, Mobile Plant Discussion Group, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Jan. 5.—NORTHERN COUNTIES BRANCH : Cleveland Scientific and Technical Institution, Middlesbrough, " Structures in Areas of Mining Subsidence," D. W. Cooper and J. D. Geddes, 6.30 p.m.

Wed., Jan. 6.—NORTHERN COUNTIES BRANCH : Neville Hall, Newcastle, " Structures in Areas of Mining Subsidence," D. W. Cooper and J. D. Geddes, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 18.—INFORMAL MEETING : Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " Radioisotopes in Industry," W. G. Busbridge, 7 p.m.

Fri., Jan. 1.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films, " Empire Links," and " Desert Bounty," 7 p.m.

Wed., Jan. 6.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, " Production Engineering in Textiles," G. A. Coglan, 7 p.m.

NEWCOMEN SOCIETY

Wed., Jan. 6.—Science Museum, London, S.W.7, " The Coalbrookdale Group Horsehay Works : Part 2," R. A. Mott, 5.30 p.m.

PLASTICS INSTITUTE

Fri., Jan. 1.—LECTURE FOR YOUNG PEOPLE : Institution of Electrical Engineers, Savoy Place, London, W.C.2, " Sticky Plastics," N. A. de Bruyne, 2.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., Jan. 6.—11, Upper Belgrave Street, London, S.W.1, " Vibration Control in Machine Foundations," J. H. A. Crockett, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Jan. 4.—ORDINARY GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, " The Effect of Industrial Development in Rural Areas," Colin Clark, 5.45 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., Jan. 6.—49, Cromwell Road, London, S.W.7, " Mountain Waves," C. E. Wallington, 5.30 p.m.

ROYAL STATISTICAL SOCIETY

To-day, Dec. 18.—INDUSTRIAL APPLICATIONS SECTION : London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, Half-day Conference on " Experimentation —in Theory and Practice," 2 to 7 p.m.

SCIENCE MUSEUM—CHRISTMAS LECTURES FOR BOYS AND GIRLS

Tues. and Wed., Dec. 22 *and* 23.—Science Museum, South Kensington, London, S.W.7, " From Man Power to Atomic Power," Victor Wall, 2.30 p.m.

Mon. and Tues., Dec. 28 *and* 29.—Science Museum, South Kensington, London, S.W.7, " From Tinfoil to Tape : The History of the Gramophone," John Cain, 2.30 p.m.

Wed. and Thurs. Dec., 30 *and* 31.—Science Museum, South Kensington, London, S.W.7, " The Story of Flight," Victor Wall, 2.30 p.m.

Fri., Jan. 1.—Science Museum, South Kensington, London, S.W.7, " Science and Magic," John Cain, 2.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Dec. 18.—Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, " Self-Fluxing Sinter," E. H. Baldwin, I. M. Mathieson and D. McNeil, 6.45 p.m.

Advanced Engineering Courses

" Predetermined Motion-Time Systems.—II. Work Factor." THE UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, " Southfield," 16, Norfolk Road, Birmingham, 15. Residential executive course from 9.30 a.m., Monday, January 11, until Friday, January 29, 1960. Fee 105 guineas.

Linear and Non-Linear Servo Control Systems. SOUTH EAST LONDON TECHNICAL COLLEGE, Lewisham Way, S.E.1. A short course of ten lectures intended to give a brief but comprehensive introduction to the principles of control engineering. Wednesday evenings, 7 to 9 p.m., commencing January 20, 1960. Fee £1.

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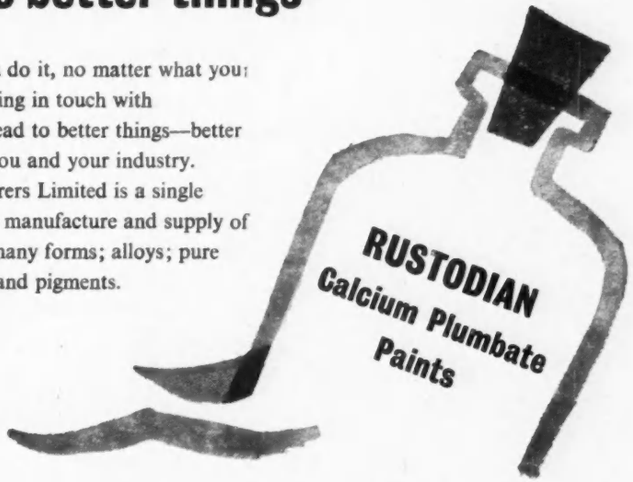

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Stephen Hales (1677 - 1761)
The first man to measure blood pressure

Although the circulation of the blood was elucidated by William Harvey in 1628, the first measurement of blood pressure was not made until 1733. In that year Stephen Hales, using two small pieces of brass pipe and a long glass tube, made a direct and accurate measurement of the blood pressure of a horse. A hundred years later came the first crude instrument for indirectly measuring the blood pressure of man, but another sixty years were to pass before anything resembling the modern sphygmomanometer had been evolved. Hales was ahead of his time because he appreciated the importance of blood pressure before most of his contemporaries were even aware of its existence.

One sees the same conditions operating in industry. For example, when the standard wiring accessory was still of metal and porcelain the Crabtree Company anticipated the demand for plastic components and installed a research laboratory, a moulding shop and a die-making plant in order to master the new technique of moulding. As a result, the Company was the first to introduce a full range of moulded wiring accessories and, in more recent years, to employ nylon for important accessory and starter components.

A determination to anticipate the future requirements of its industry has always marked the activities of this Company.

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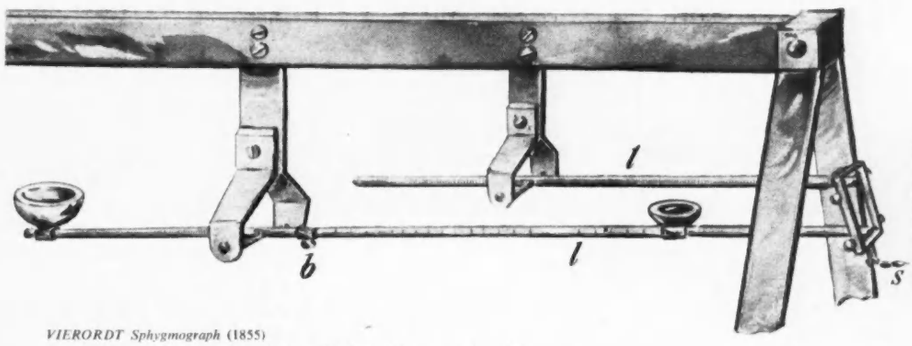
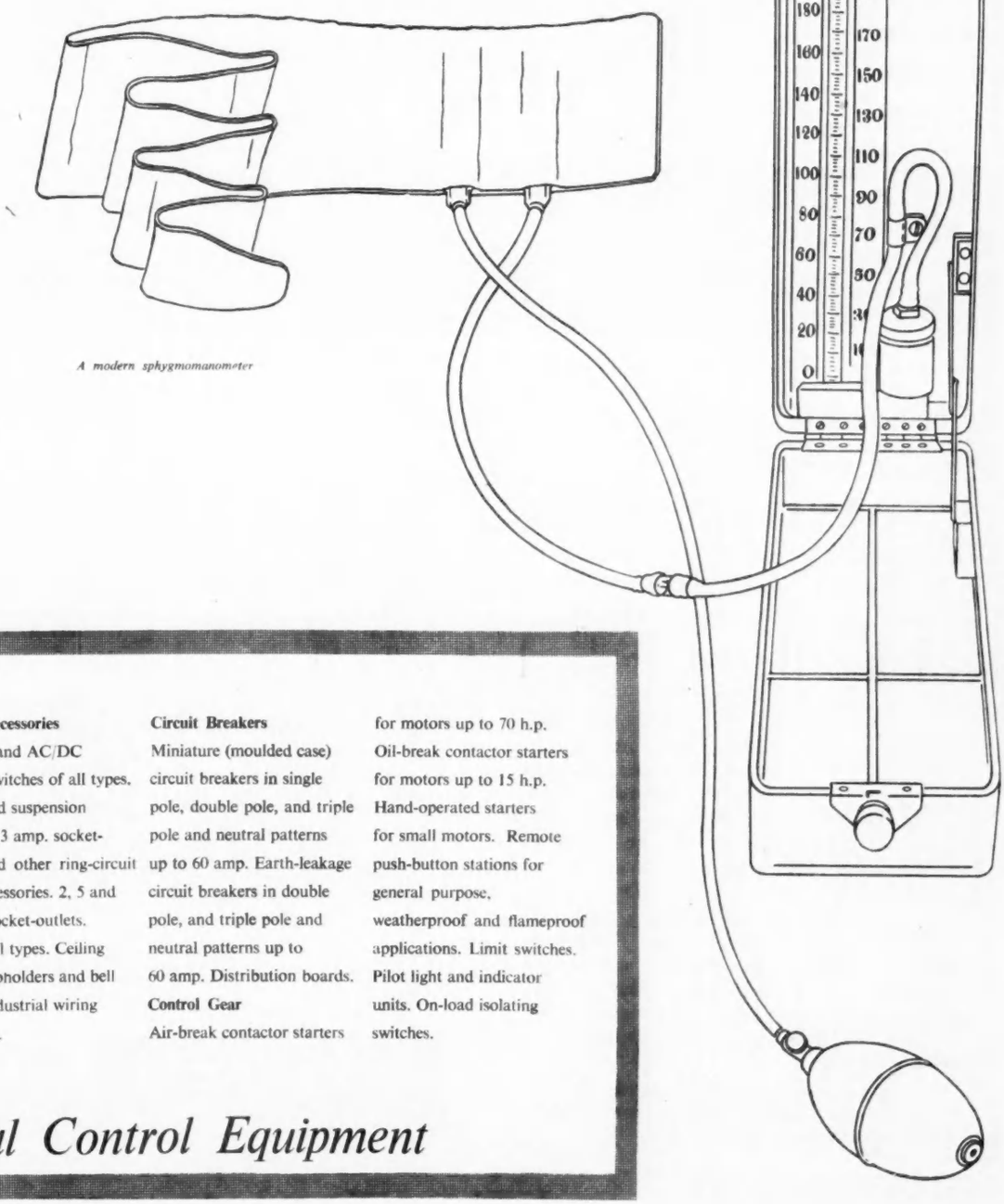


VIERORDT Sphygmograph (1855)
b - metal button. l - metal bar with plates to hold weights. s - writing point.

Metal button applied to radial artery; amount of weight required to obliterate radial artery pulsations taken as index of systolic pressure.

(With acknowledgements to "Normal Blood Pressure and Hypertension" by Arthur M. Master, Charles I. Garfield and Max B. Walters; London: 1952, Henry Kimpton.)



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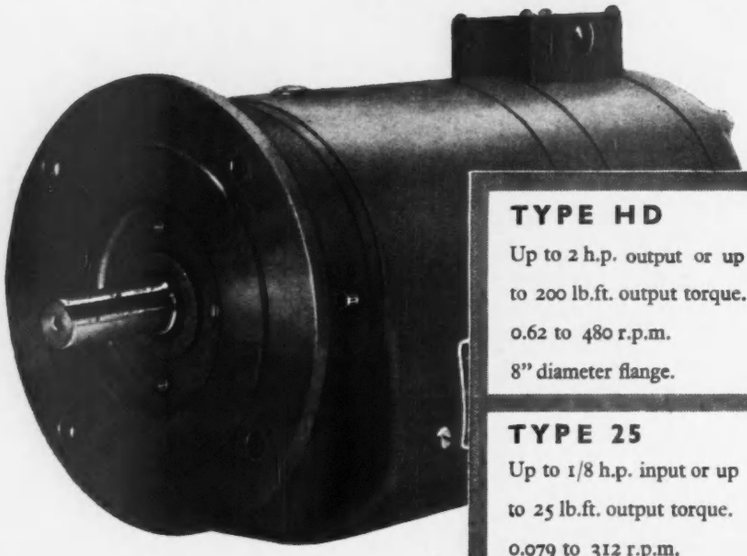

TYPE HD

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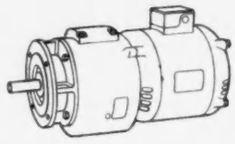

TYPE 25

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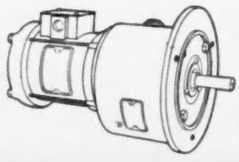

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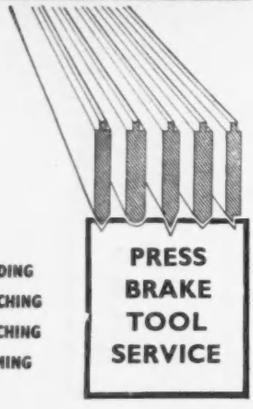

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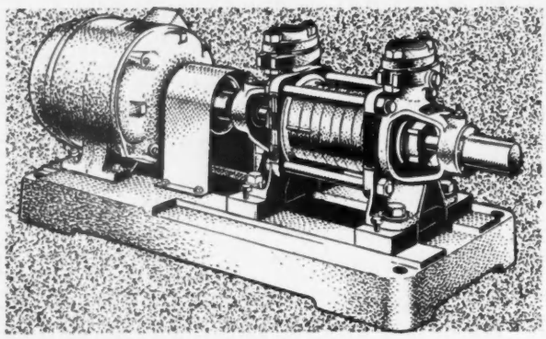

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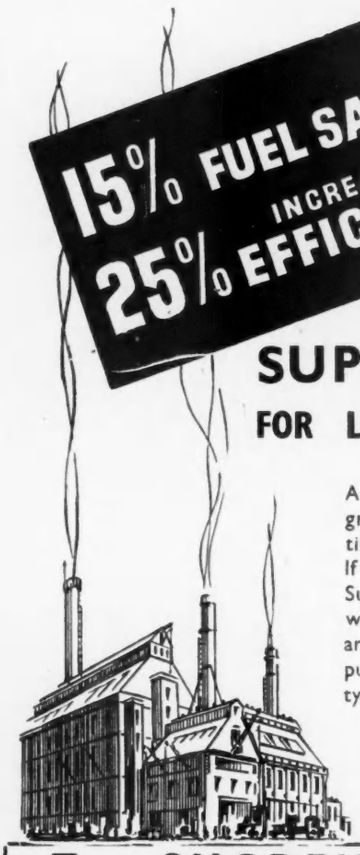

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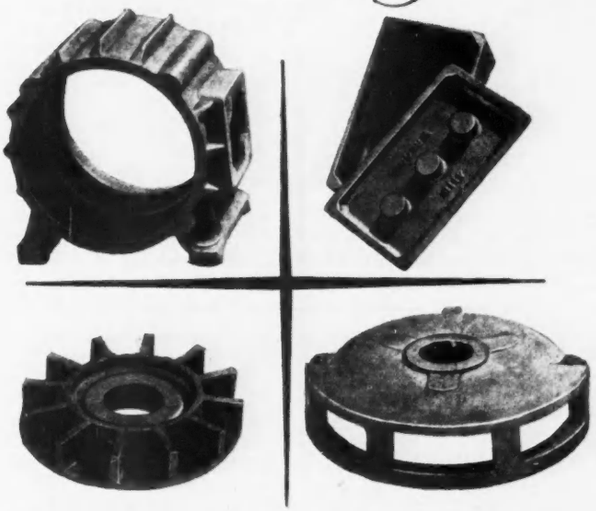

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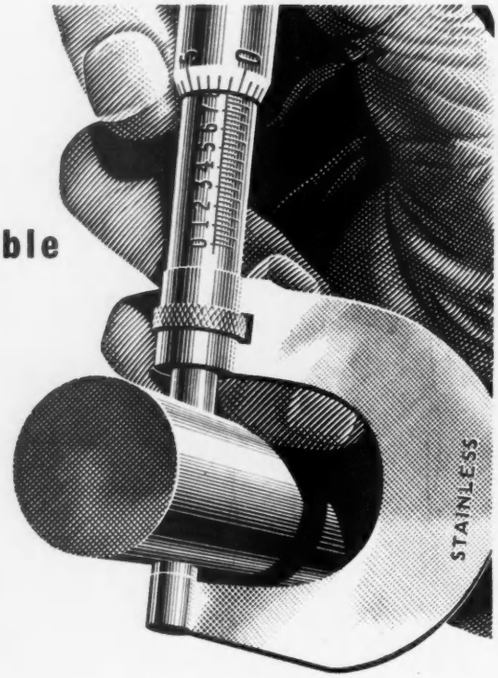

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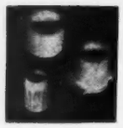

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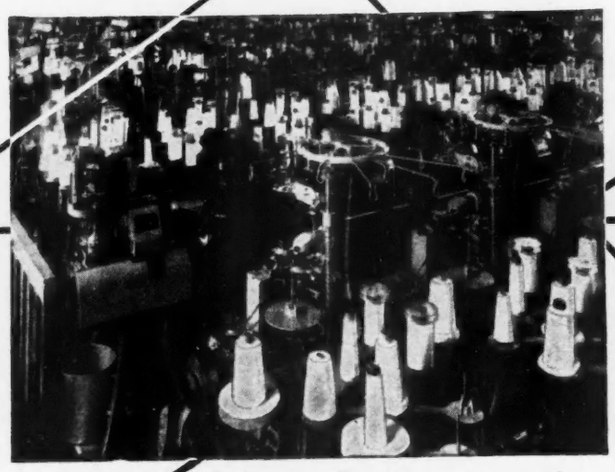

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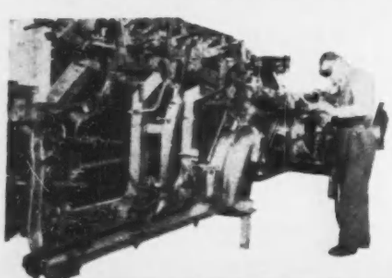

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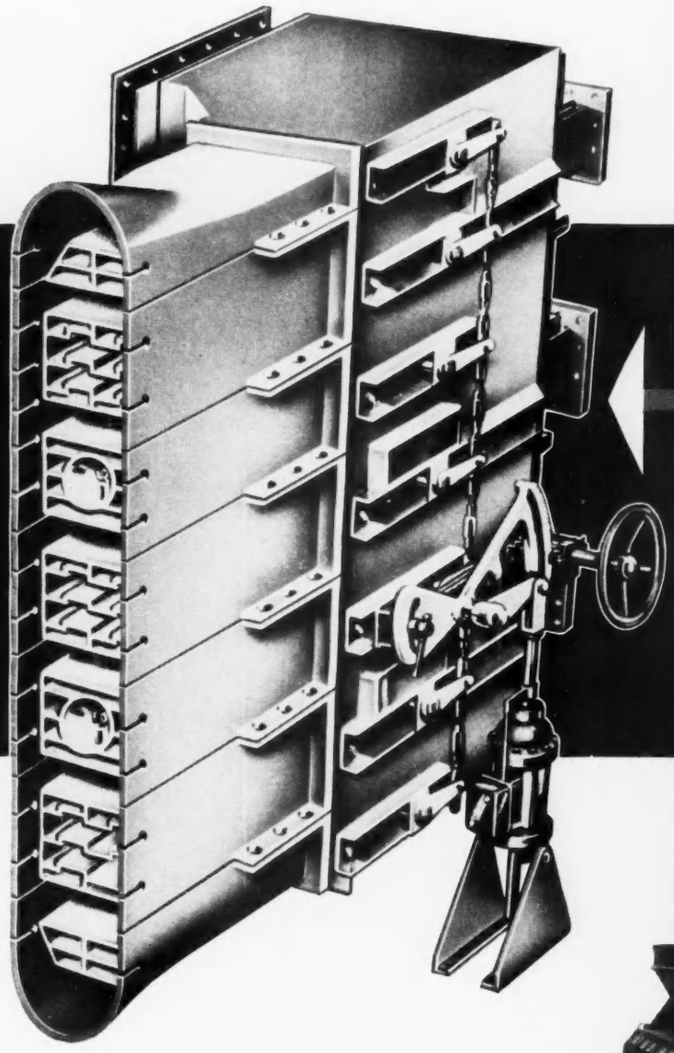

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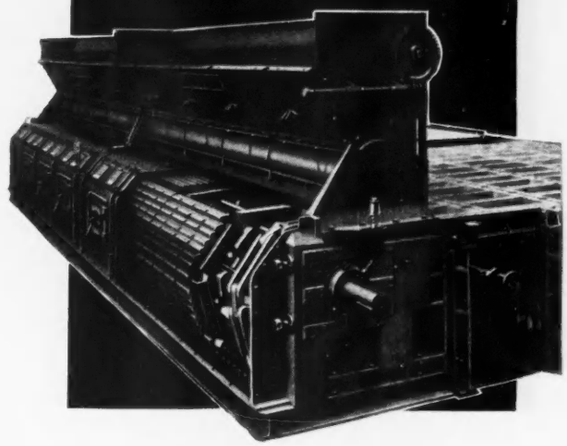

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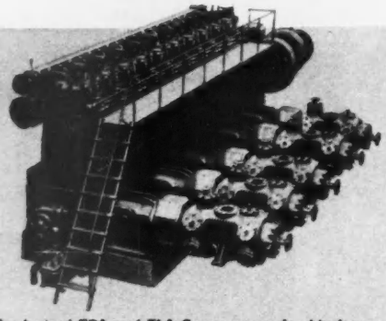
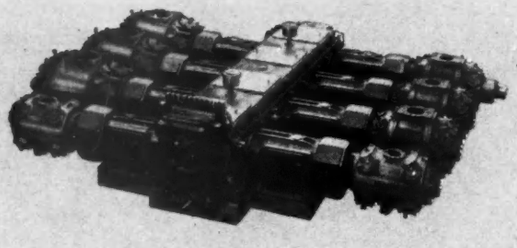
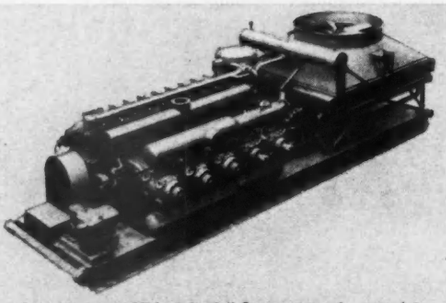


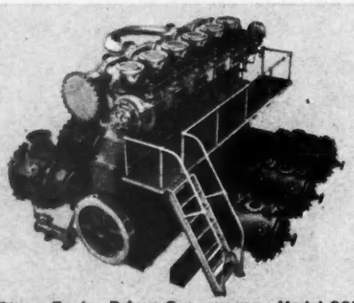
Turbocharged TRA and TLA Compressors for big horsepower requirements at moderate to high compression ratios, or where extreme flexibility of compressor cylinder loading is essential. Model TRA available with 6, 8, 10 cylinders, 1100 to 1800 bhp. Model TLA available with 5, 6, 8, 10 cylinders, 1700 to 3400 bhp.



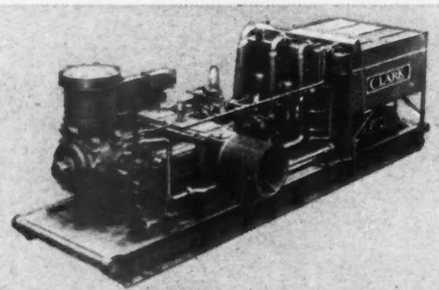
Model CMA, CMB, CLRA and CLBA Motor-Driven Compressors for extremely high pressures, or where a number of gas streams must be handled simultaneously. Available with 2 to 10 compressor cylinders, depending on model chosen. Six stroke sizes: 6", 8", 8¾", 11", 14" and 17". Pressures from vacuum to over 36,000 psi.



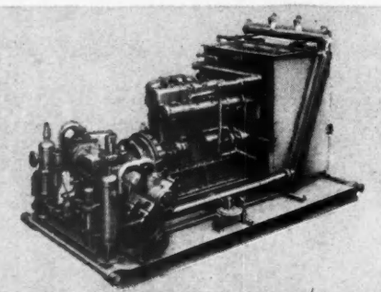
Skid Mounted "Midget Angle" Compressors for complete compressor stations with portability. Skid contains compressor, radiator, scrubbers and all necessary auxiliaries. Models HMB and TMB from 330 to 660 bhp. Model HMA available with 175, 265, 350 and 440 bhp.



Steam-Engine-Driven Compressors. Model SCRA has "Right Angle" Unaflow design. Proved an ideal compressor in process industries for synthesis applications. Model SCRA available in units with 2, 3, 4, 5, 6 and 8 compressor cylinders, each with 500 to 3200 bhp.



Air-Drilling Compressors, especially designed for aerated mud drilling. Air-Pac model is "packaged", skid mounted compressor station containing balanced/opposed compressor, radiator, necessary auxiliaries. Completely automatic 550 bhp unit is belt driven from draw works compound.



Skid Mounted Engine-Driven Compressors for field gas gathering and gas lifting. "Packaged" Model CFA provides balanced/opposed compressor, radiator, scrubbers, auxiliaries, with choice of gas, gasoline or diesel engine drive. Available with 2 or 4 cylinders, horsepower range from 100 to 364 bhp.

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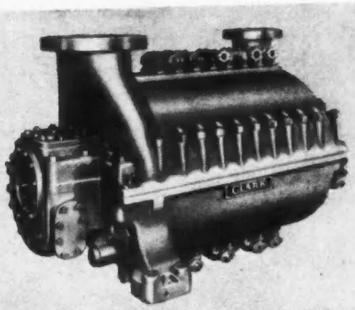
While Clark compressors long have been widely used in the gas, oil, chemical, process and general industrial fields, they have recently been finding an important place in the field of nuclear energy.



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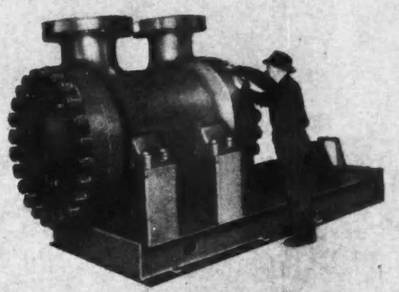
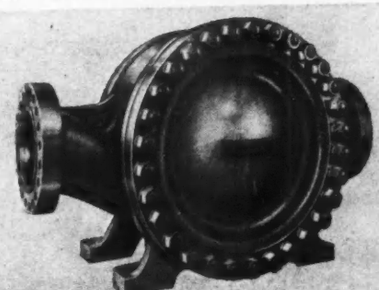


Vertically-Split Centrifugal Compressors. Multi-stage units for extremely high pressures. Four case sizes. Capacities range from 200 cfm measured at discharge conditions to 20,000 cfm measured at suction conditions.



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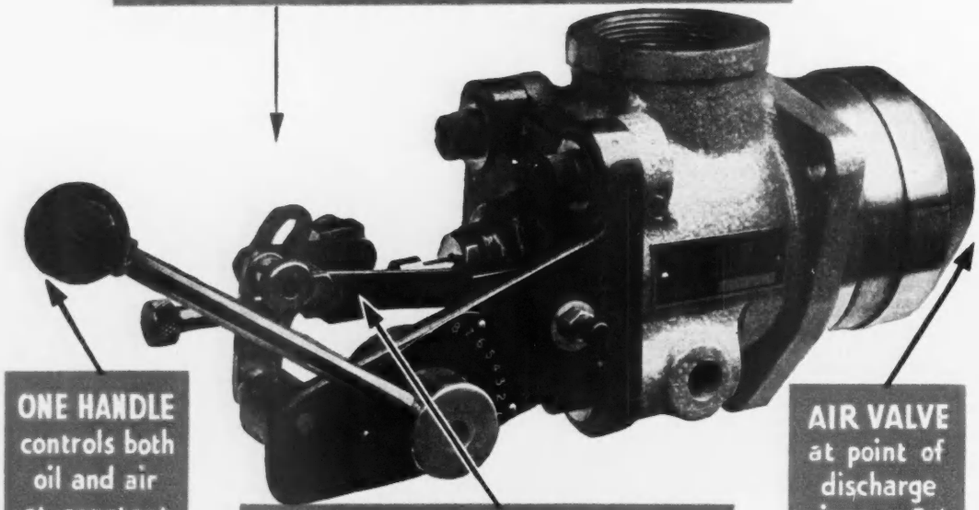

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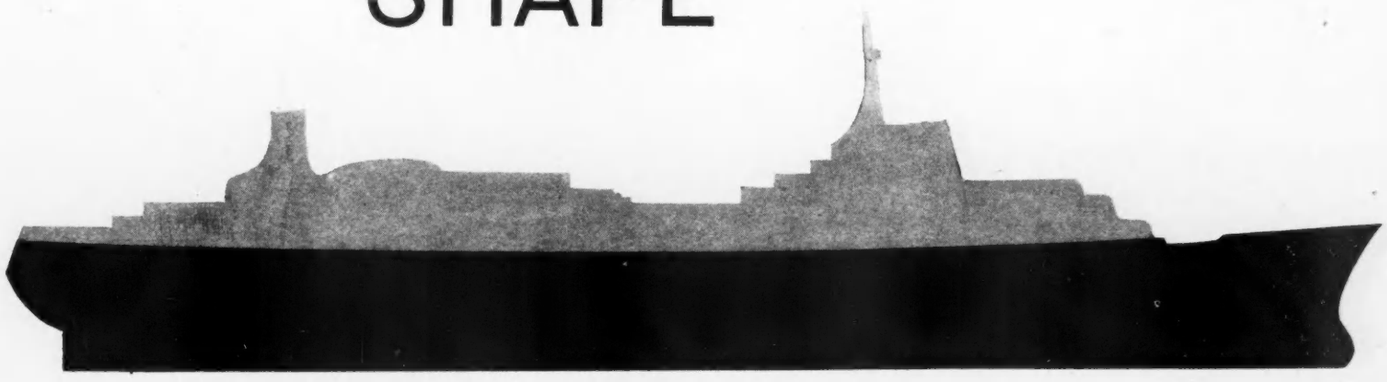

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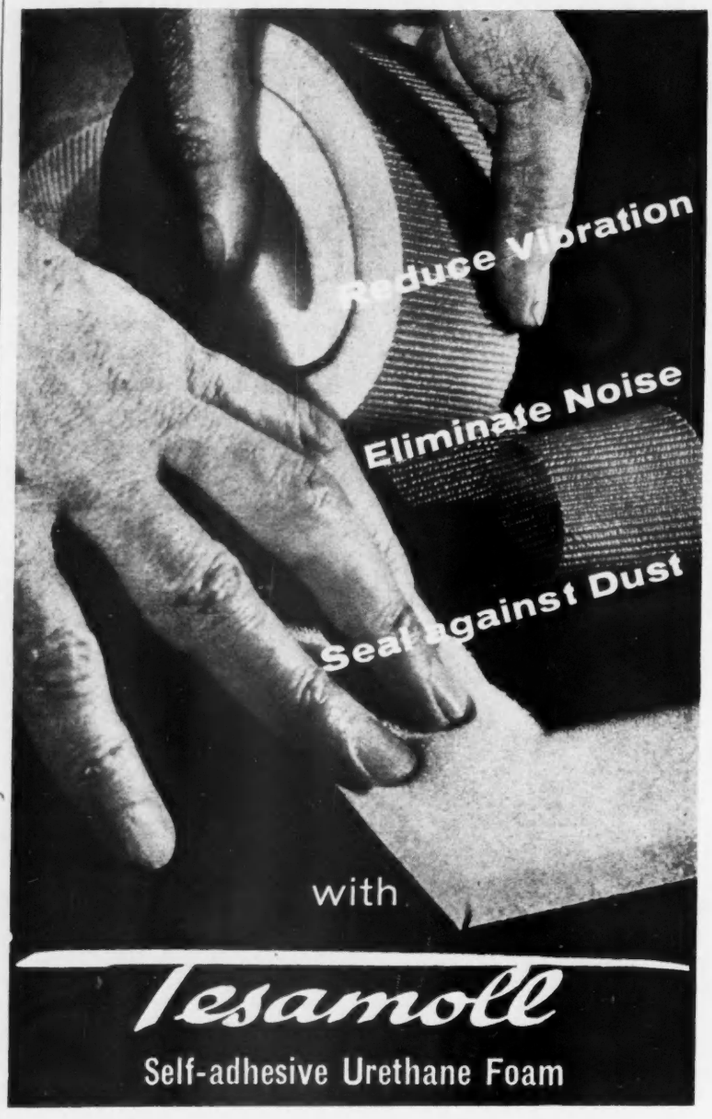

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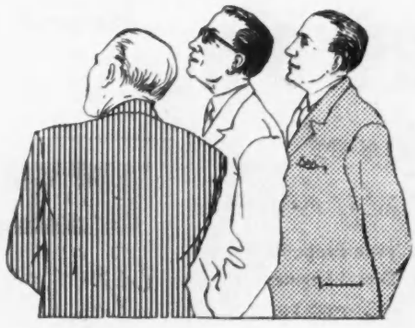

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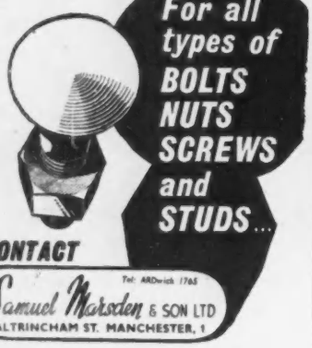

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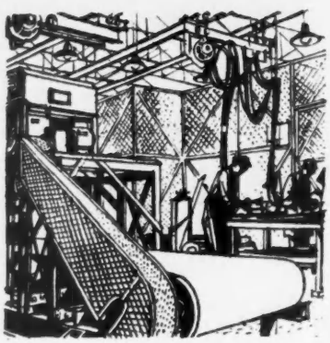

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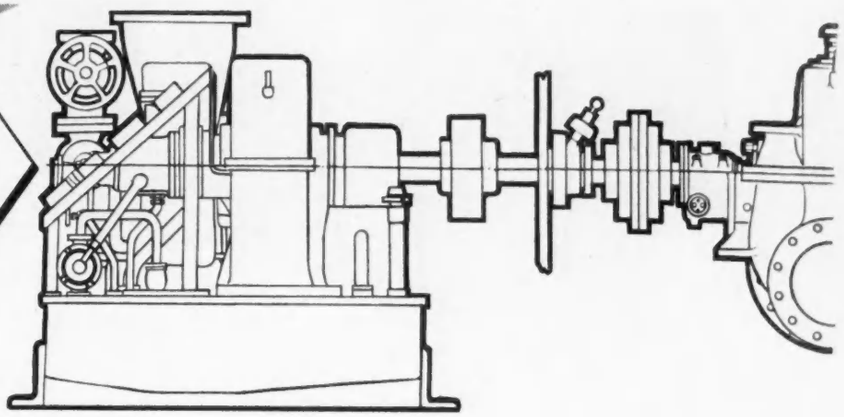

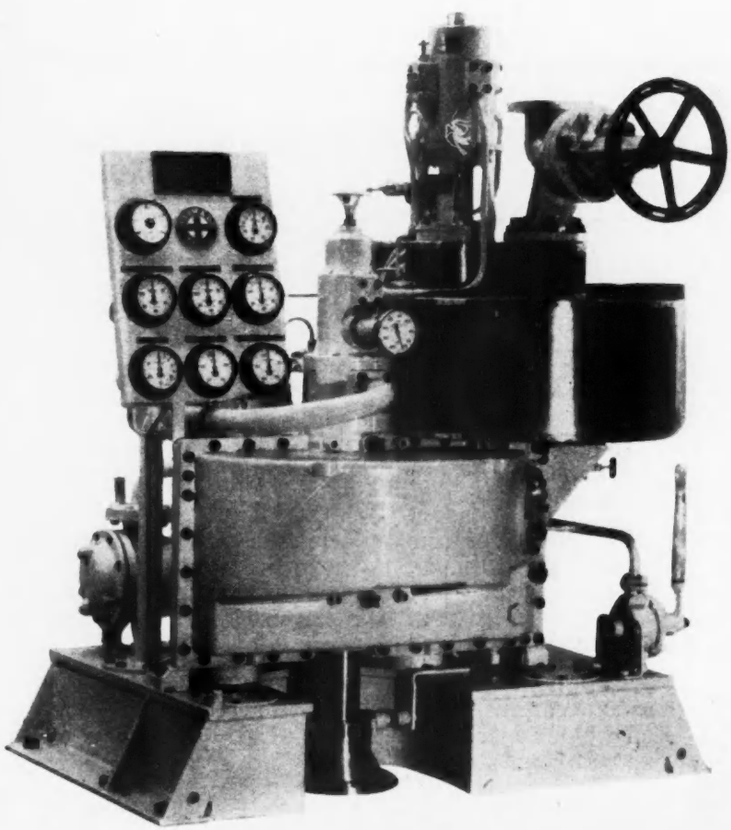

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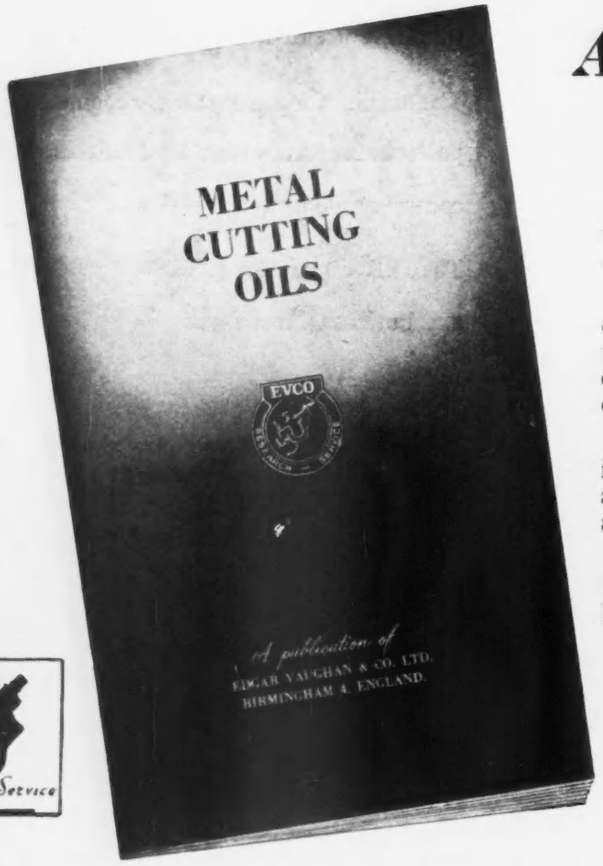

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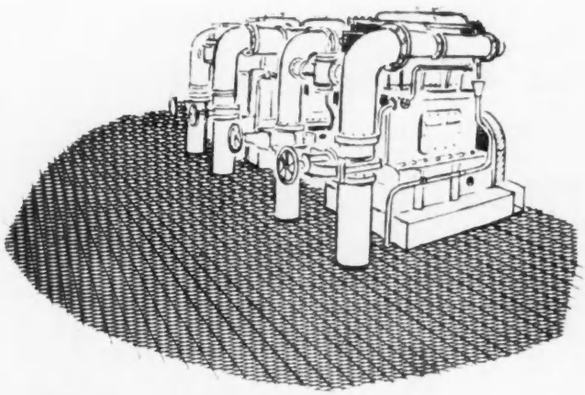

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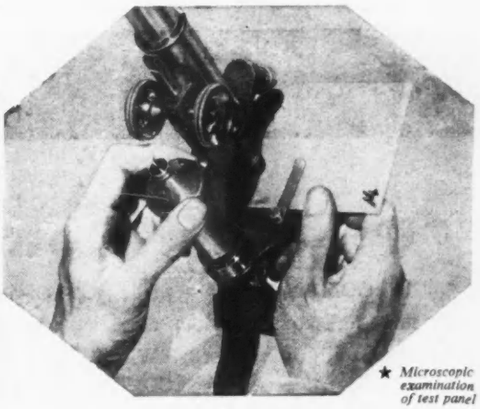

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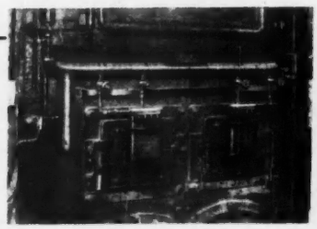

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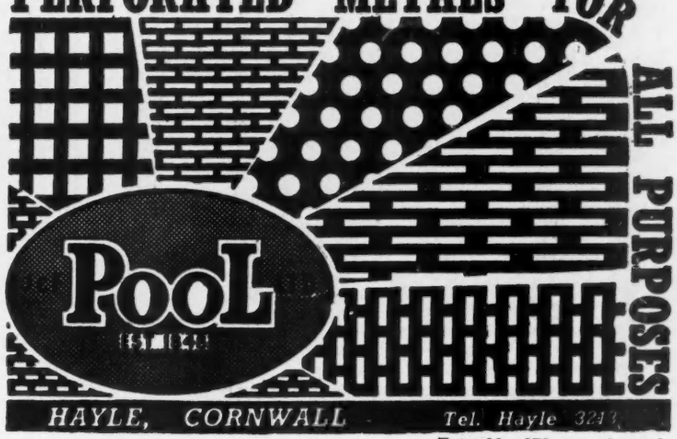

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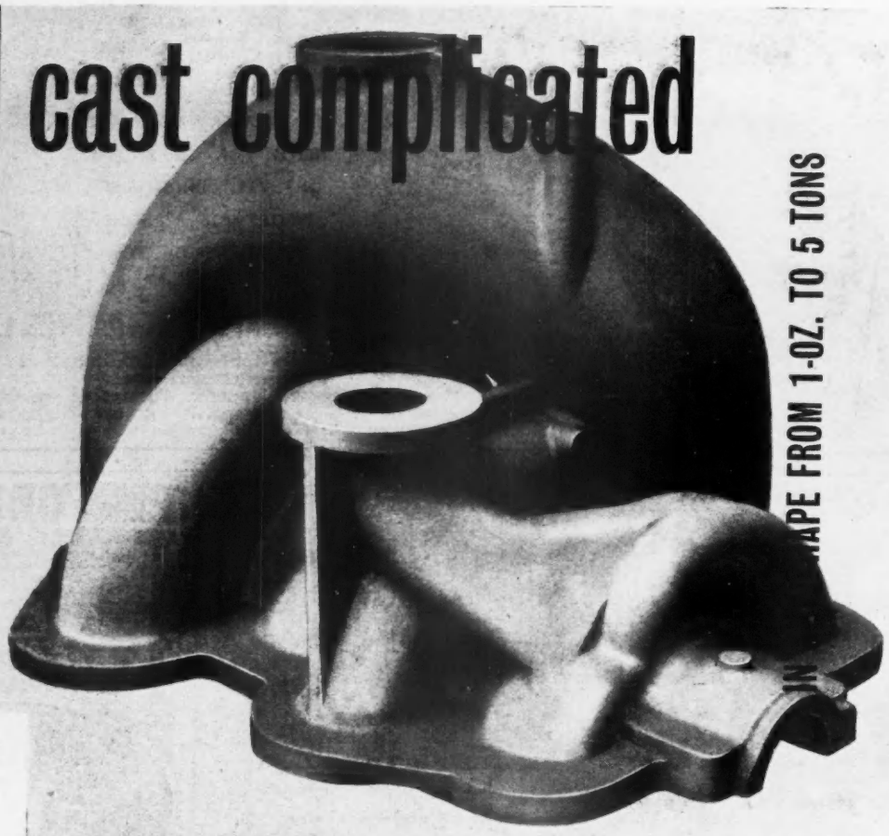

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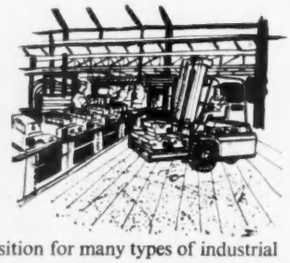

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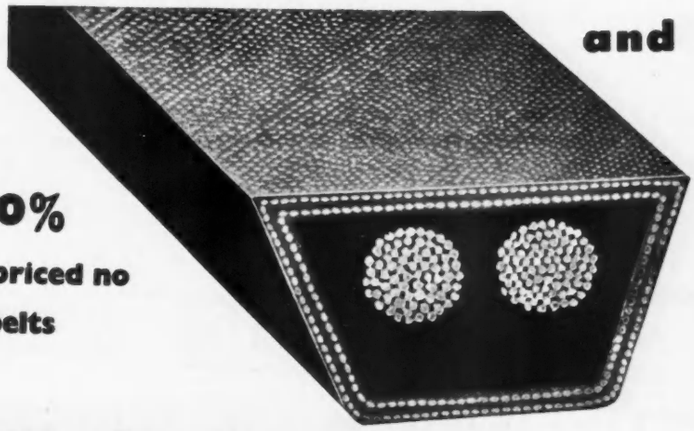

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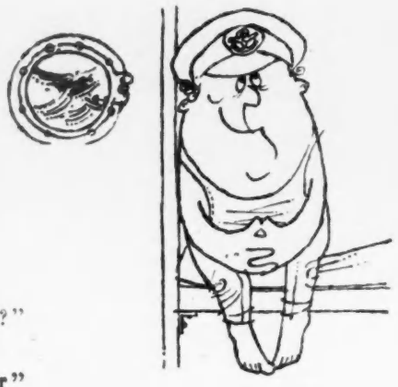

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"Ever hear anything so smooth and solid?"

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"Band? I thought you were talking about the engines since we fitted L & C Piston Rings!"

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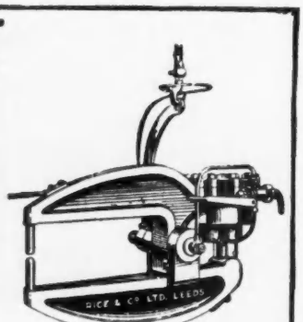

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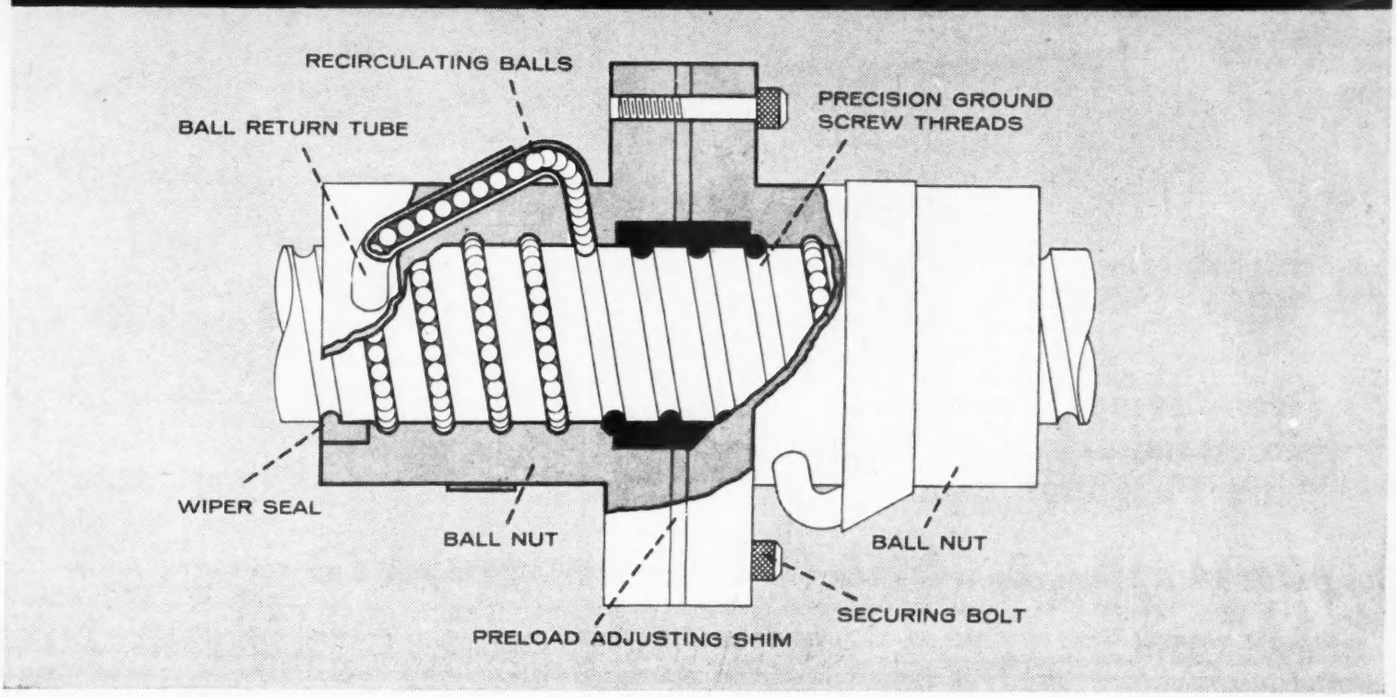

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Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

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Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

* *Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

For further information please write to:

J. B. STARKY, SALES MANAGER (BEAVER PRODUCTS DIVISION), BRISTOL SIDDELEY ENGINES LIMITED, PO BOX 17, COVENTRY, ENGLAND.

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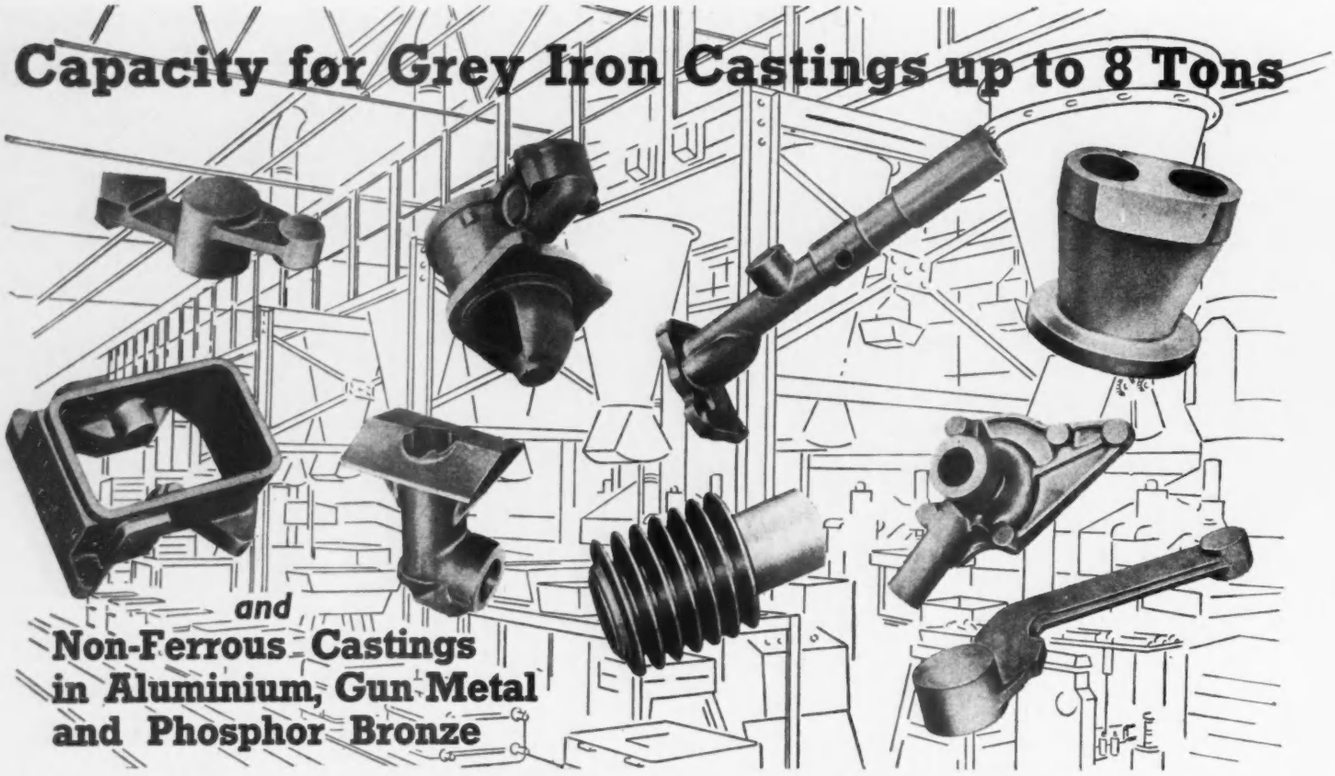

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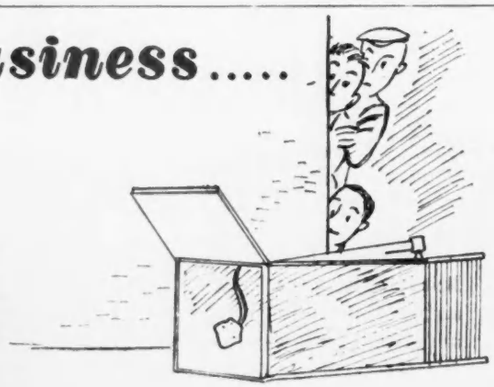

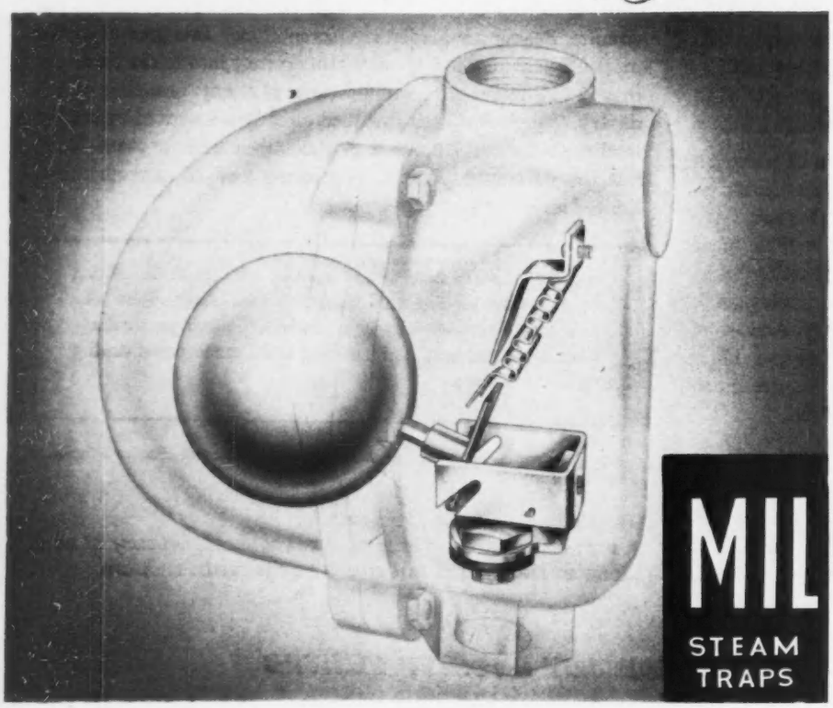

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Tangye Jack

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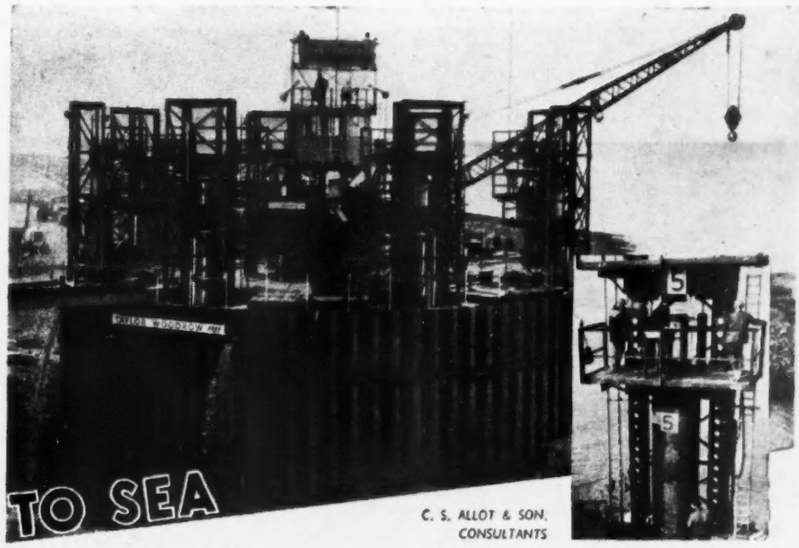

C. S. ALLOT & SON, CONSULTANTS

This reinforced concrete cooling water intake caisson at Hinkley Point Atomic Power Station was built by Taylor Woodrow Construction Ltd., who, in association with the English Electric Company and Babcock & Wilcox Ltd., are responsible for the design and construction of this 500 MW station for the Central Electricity Generating Board. It weighs nearly 4,000 tons, and was towed out to its position in the Bristol Channel where it was lowered on eight hydraulically operated "spud legs" to the sea bed. TANGYE HYDRAULIC POWER IN THE FORM OF EIGHT 500 TON JACKS INCORPORATED IN THE LEGS WERE THEN OPERATED TO LEVEL THE STRUCTURE.

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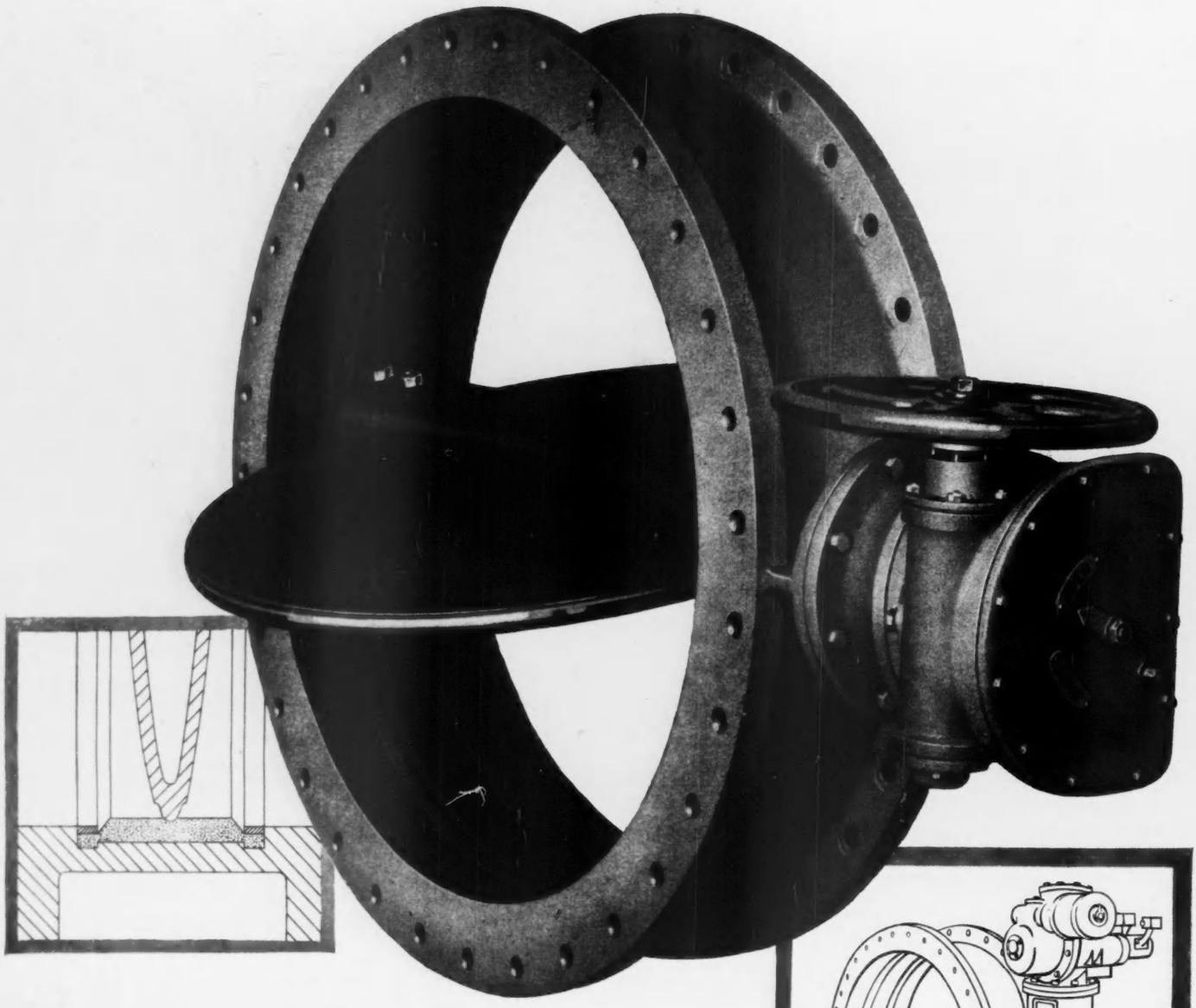

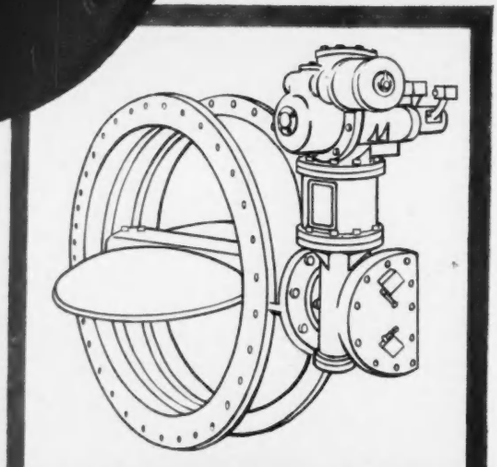

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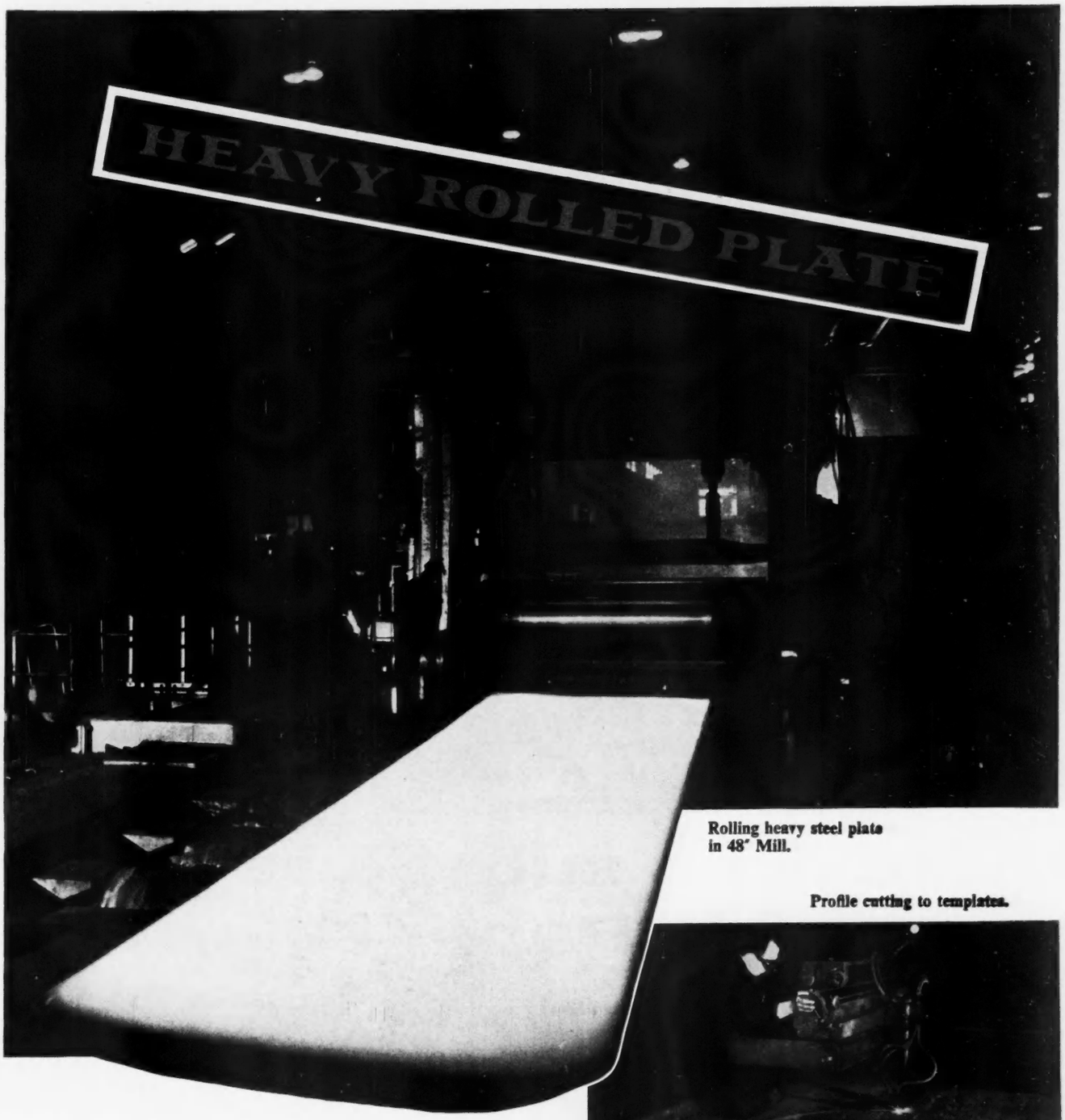

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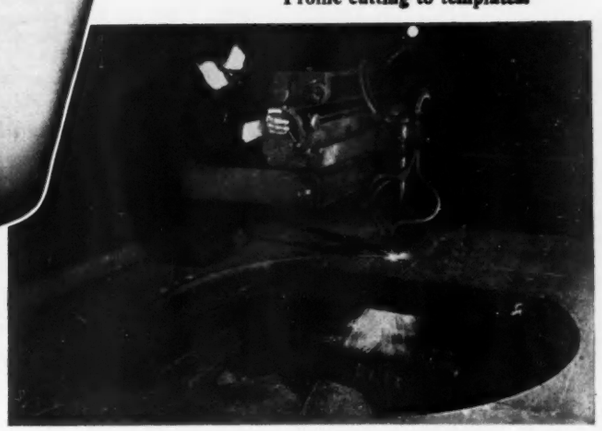

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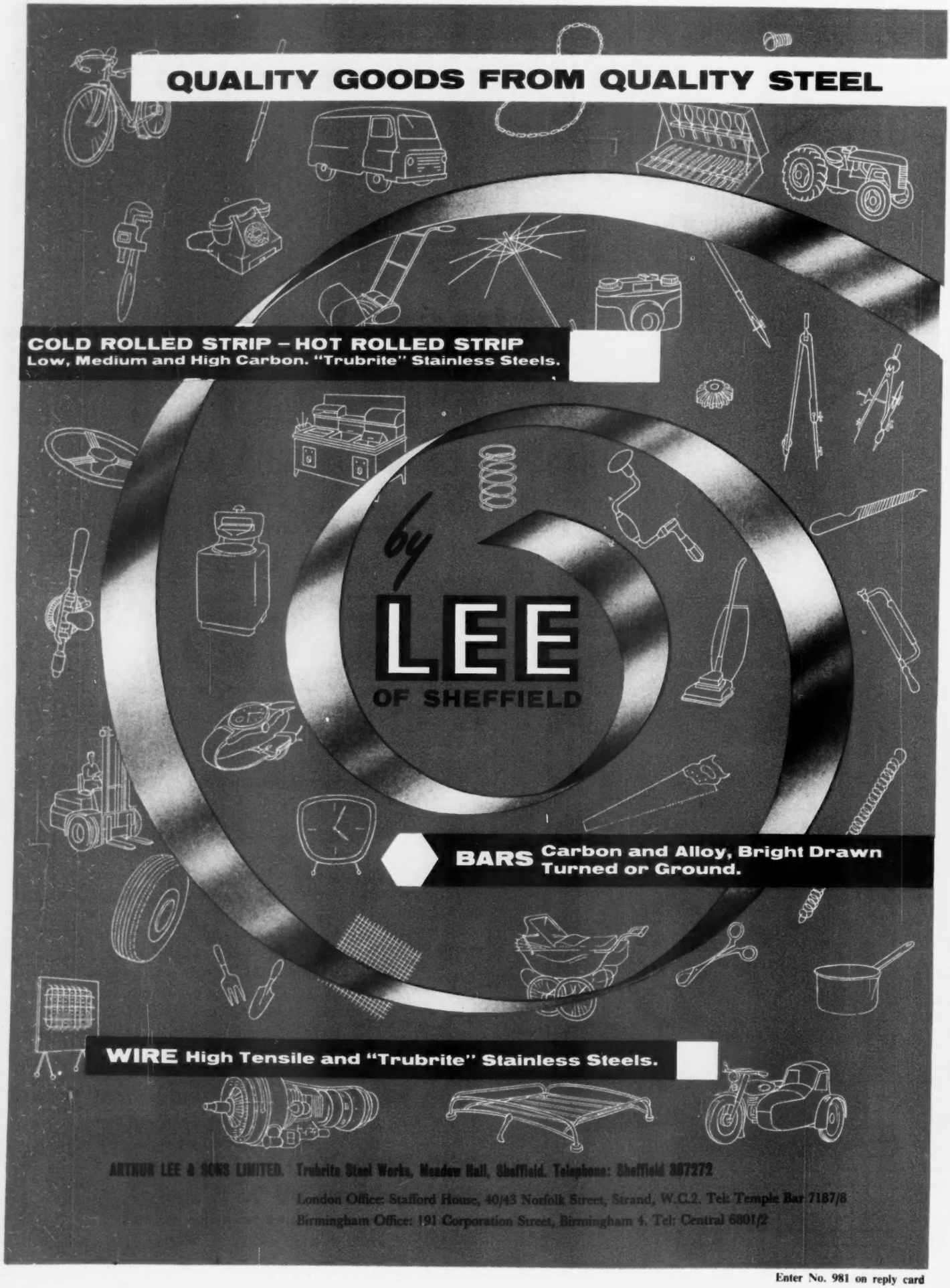
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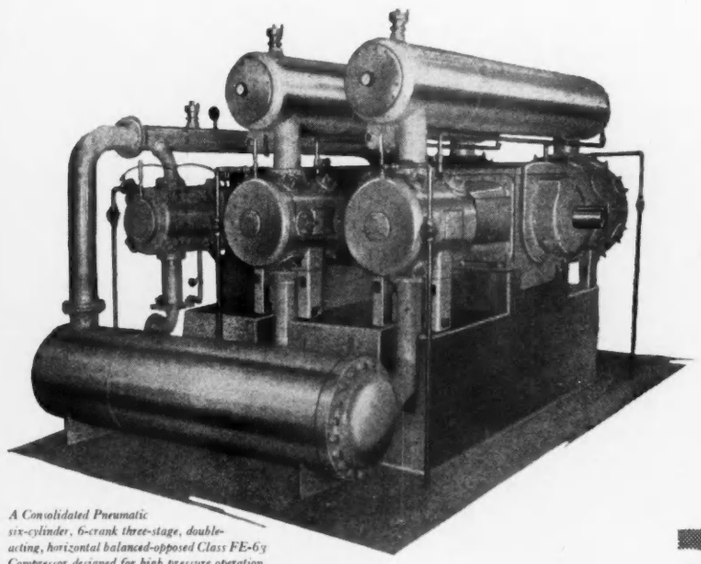
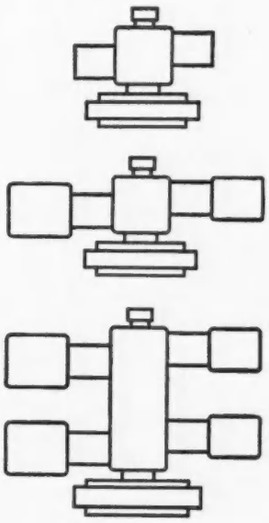
The adaptability of Standard "FE" compressor units brings you AIR AT LOWER COST * up to 5000 c.f.m. or 3000 p.s.i.

* *Class "FE" compressors are suitable for handling gasses other than air.*



A Consolidated Pneumatic six-cylinder, 6-crank three-stage, double-acting, horizontal balanced-opposed Class FE-6y Compressor designed for high pressure operation.



1. The basic Class "FE" crankcase and running gear, showing also compactness achieved by using engine-type, salient-pole motor.

2. Different-size cylinders can be fitted, one-, two-, three- or four-stage machines being available.

3. Large outputs are obtained by increasing the number of cylinders and working off a common crankshaft.

The advantage of standard Consolidated Pneumatic "FE" class compressor units is that they can be built up into single or multi-stage installations giving outputs up to 5,000 c.f.m. or pressures up to 3,000 p.s.i. to suit *exact individual* requirements, thus giving the most efficient return in terms of air delivered for power consumed. And, because the machines consist of standard units, the basic engineering cost of the plant as a whole is lower. Further, the virtues of the balanced-opposed design of these units are such as to effect considerable savings in foundation work, floor space and maintenance costs. In every way, "FE" compressors mean air at lower cost.

Advantages of the balanced-opposed design

In the "FE" compressors, the crankcase and frame are centrally positioned with cylinders on opposing sides, the drive being obtained by a double-throw crankshaft. The resulting perfect dynamic balance makes for far greater compactness and virtual freedom from vibration, space and foundation work being reduced to a minimum. Also, the considerably smaller load imposed on main bearings, together with slow operating speed, ensure an extremely long life of continuous operation with very little maintenance.

FOR FURTHER INFORMATION complete this form and pin it to your letter heading.

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CONSOLIDATED PNEUMATIC TOOL COMPANY LIMITED, DAWES ROAD, LONDON, S.W.6.

This form will bring you a descriptive catalogue on Class "FE" Compressors, but if you would like advice on a projected plant, your enquiry can be dealt with more expeditiously if the following information can be provided:-

1. Output required in cubic feet per minute at intake pressure and temperature. _____
2. Intake temperature and humidity. _____
3. Intake pressure. _____
4. Discharge pressure. _____
5. Type of drive motor, voltage, etc. _____
6. Temperature of cooling water and type of cooling circuit. _____
7. Aftercooler, if required, and temperature of air at discharge from aftercooler. _____
8. Purpose for which compressor is to be used. _____

23

CP167

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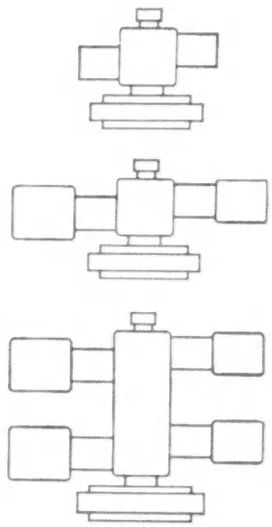
The adaptability of Standard "FE" compressor units brings you AIR AT LOWER COST * up to 5000 c.f.m. or 3000 p.s.i.

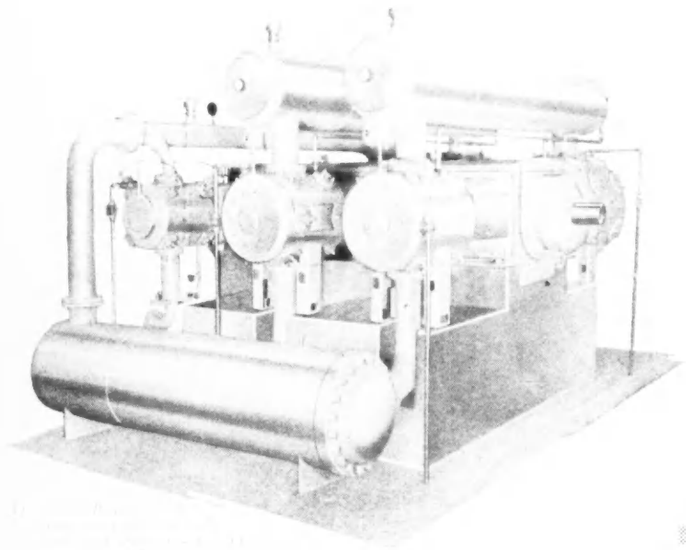


1. The basic Class "FE" crankcase and running gear, showing alternative types adapted to take engine-type salient-pole motor.

2. Different cylinder blocks can be fitted—cross-two-, three-in-line—to suit machine best available.

3. Three output pre-designed by varying the number of cylinder assemblies on a common crankshaft.

* *Class "FE" compressors are suitable for handling gasses other than air.*



The advantage of standard Consolidated Pneumatic "FE" class compressor units is that they can be built up into inside or multi-stage installations giving outputs up to 5,000 c.f.m. or pressures up to 3,000 p.s.i. to suit *exact individual* requirements, thus giving the most efficient return in terms of air delivered for power consumed. And, because the machines consist of standard units, the basic engineering cost of the plant as a whole is lower. Further, the virtue of the balanced-opposed design of the compressors is such as to effect considerable savings in foundation work, floor space and maintenance costs. In every way, "FE" compressors mean air at lower cost.

Advantages of the balanced-opposed design

In the "FE" compressors, the crankcase and frame are centrally positioned with cylinders on opposite sides, the drive being obtained by a double-throw crankshaft. The resulting perfect dynamic balance makes for far greater compactness and virtual freedom from vibration, space and foundation work being reduced to a minimum. Also, the considerably smaller load imposed on main bearings, together with slow operating speed, ensure an extremely long life of continuous operation with very little maintenance.

FOR FURTHER INFORMATION complete this form and pin it to your letter heading.

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1. Output required in cubic feet per minute at intake pressure and temperature
2. Intake temperature and humidity
3. Intake pressure
4. Discharge pressure
5. Type of drive—motor, voltage, etc.
6. Temperature of cooling water and Max. Dew Point (°C.)
7. Aftercooler, if required, and temperature of air at discharge from aftercooler
8. Purpose for which compressed air is to be used

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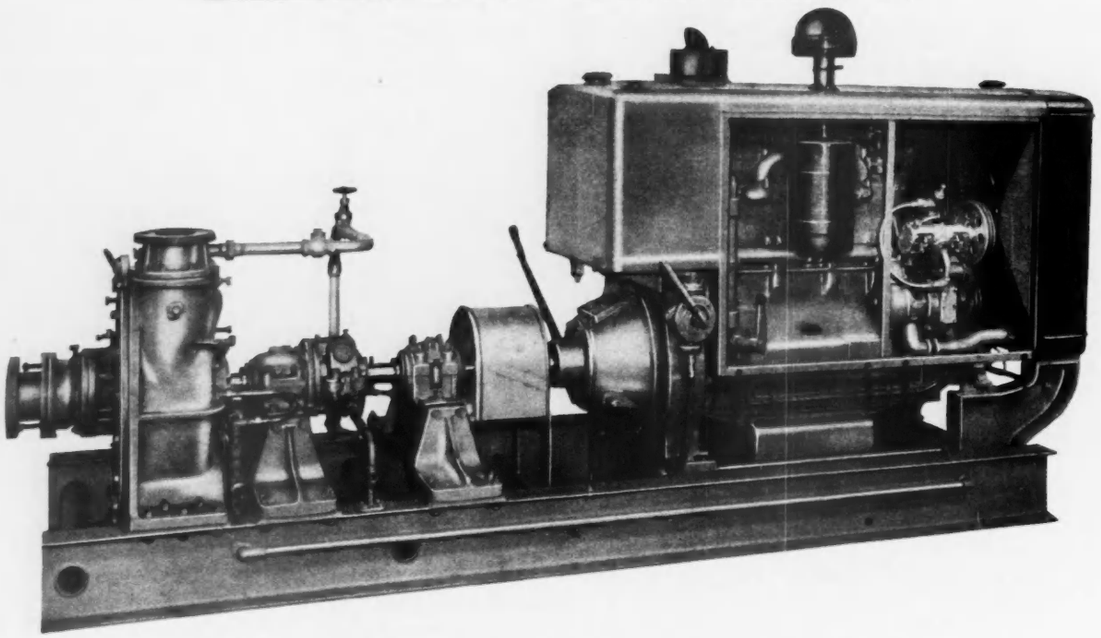

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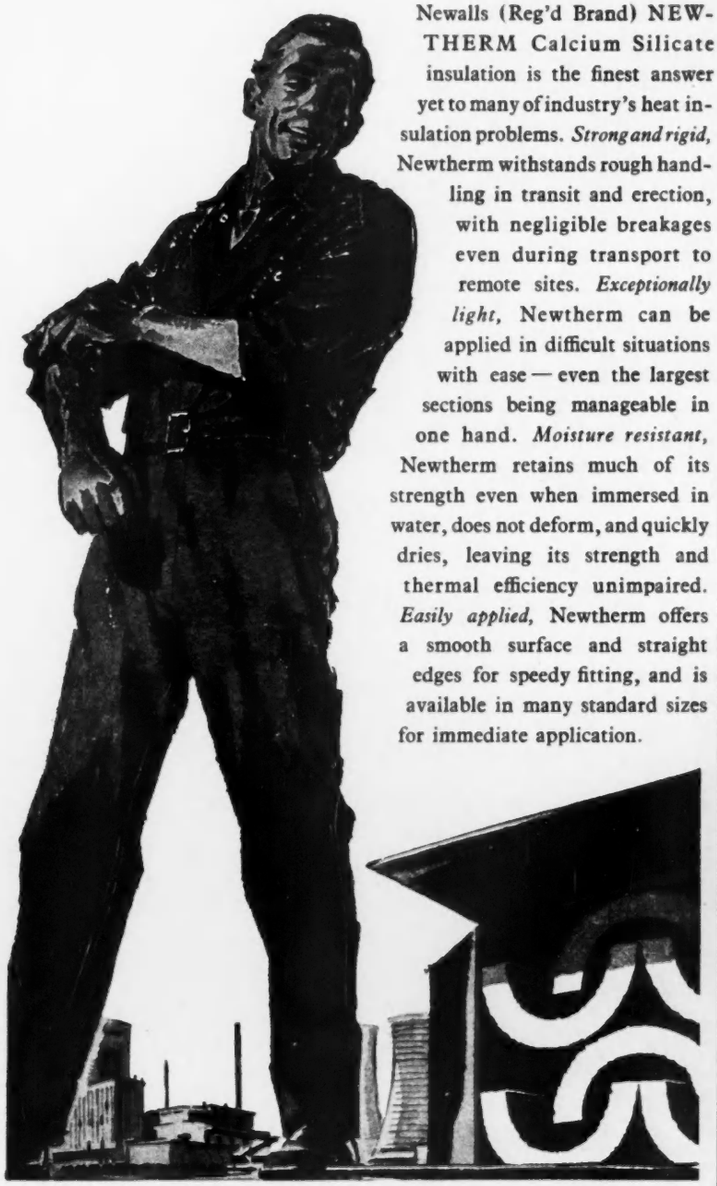

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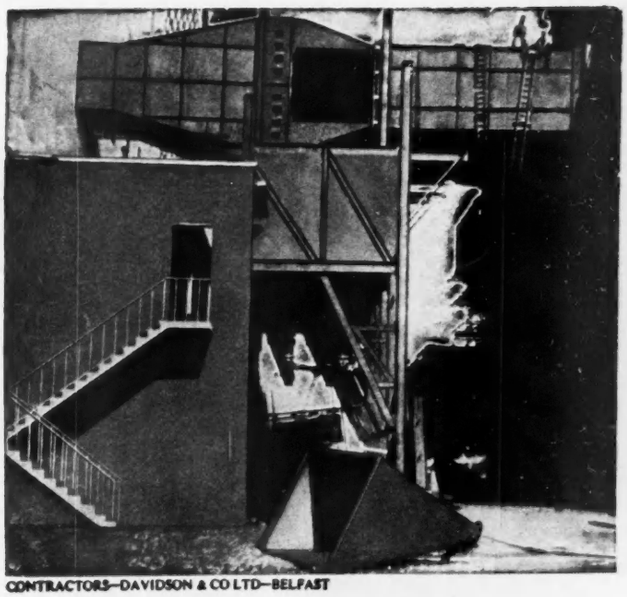

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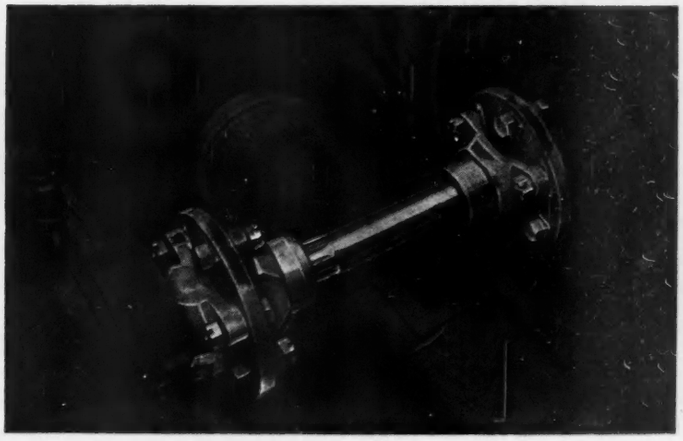
through the medium of
FLEXIBLE FABRIC COUPLING DISCS



★ Are easily assembled.
★ Give extreme torsional flexibility.
★ Absorb irregularities in load variations.
★ Axial and parallel misalignments are corrected.

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Big civil engineering contracts call for light railway equipment that will give long trouble-free service under tough working conditions.

That's why Hudson trucks were used on the contract for the building of Ghana's new deepwater harbour at Tema.

ROBERT HUDSON LTD. RALETRUX HOUSE MEADOW LANE, LEEDS.
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LIGHT RAILWAY MATERIALS

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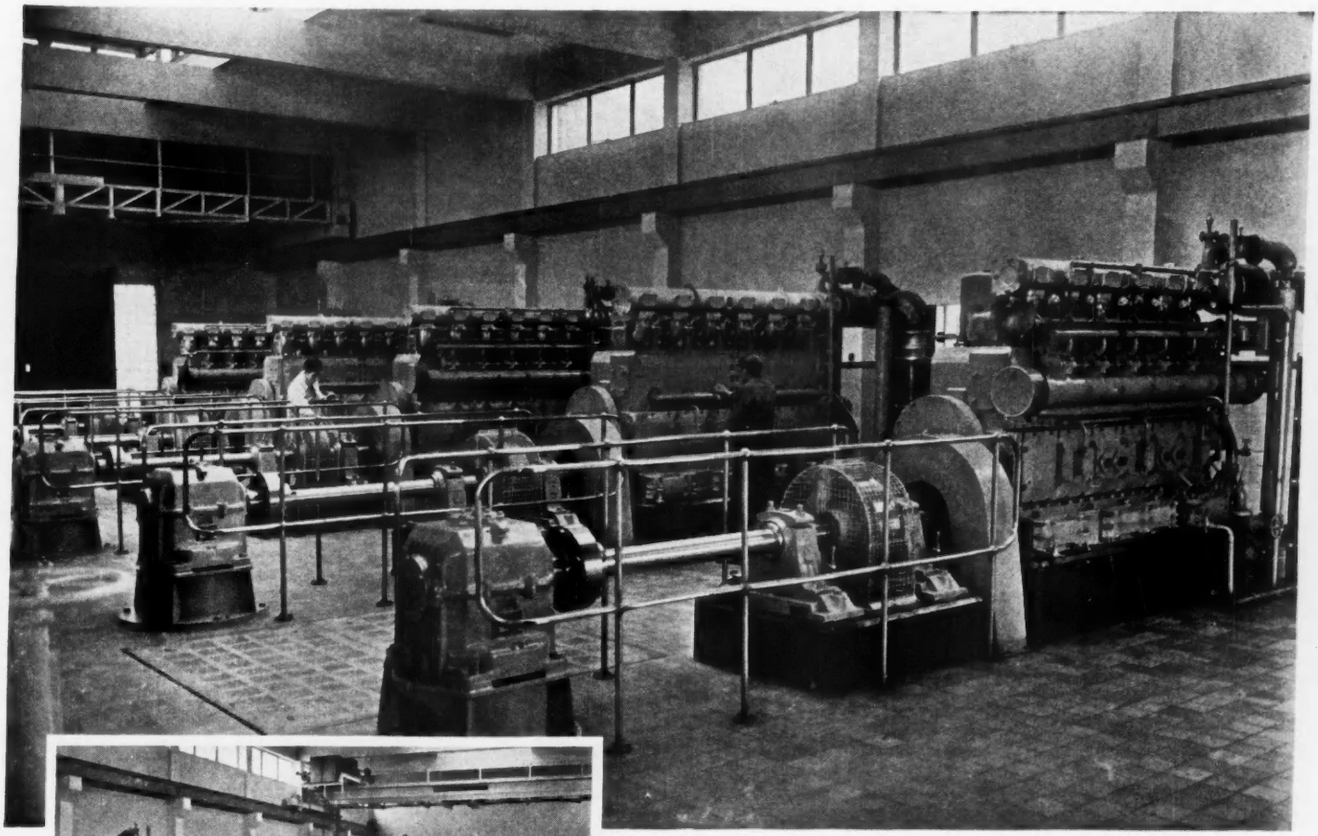

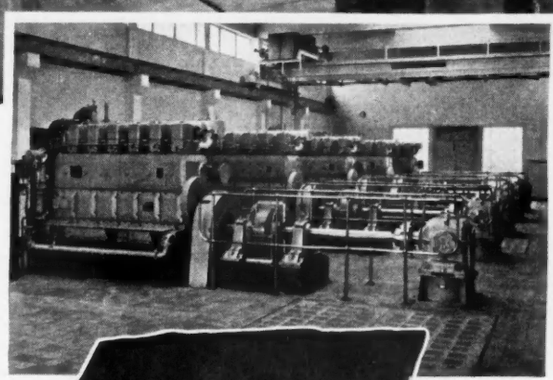

DERBY RELY ON NATIONAL ... the pioneers of Dual-Fuel engines

This is where reliability counts

Maximum reliability—a failure of power for even a short period could increase river pollution beyond the specified maximum—that is why the Derby Corporation decided on dual-fuel engines in their new sewage disposal plant at Spondon Works.

The pumping station houses five National engines each driving through David Brown speed increasing gears, a vertical shaft single stage multiflow pump rated at 2 m.g.d. supplied by W. H. Allen, Sons & Co. Ltd.

Three of the engines are designed to run on a mixture of sludge gas and diesel oil and two as straight diesel engines. All five engines have a continuous rating of 231 b.h.p. at 600 r.p.m.

Details of National dual-fuel engines ranging from 156 to 1248 b.h.p. will be supplied on request.

NATIONAL

THE NATIONAL GAS AND OIL ENGINE CO., LTD., ASHTON-UNDER-LYNE, LANCASHIRE.

Overseas Organisation : HAWKER-SIDDELEY BRUSH INTERNATIONAL LTD., NATIONAL WORKS, ASHTON-UNDER-LYNE, ENGLAND

A member of the Hawker Siddeley Group

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equipment for the
continued production of
SUPERIOR DROPFORGINGS

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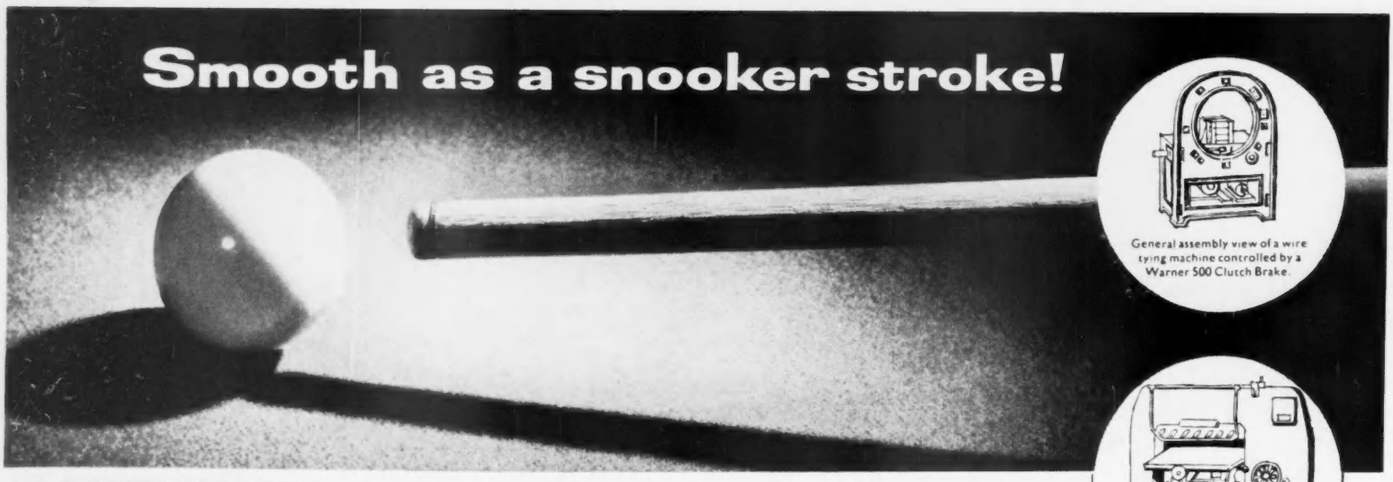
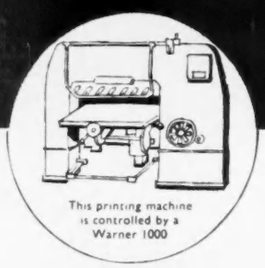


General assembly view of a wire tying machine controlled by a Warner 500 Clutch Brake.



This printing machine is controlled by a Warner 1000

WARNER Electric Brakes & Clutches

Warner Electric Brakes and Clutches are manufactured in Gt. Britain under licence by:

WESTOOL LIMITED

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Phone: West Auckland 551 5
Grams: Solenoid, West Auckland

LONDON: 2 Ashley Place, Carlisle Place, London, S.W.1
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BIRMINGHAM: 7 Newhall St., Birmingham 3
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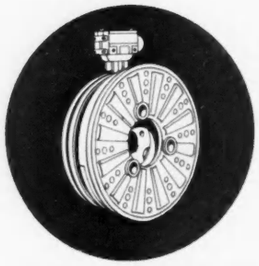
Acceleration and deceleration present no problems when machines are controlled by Warner units. They give instantaneous response—without shock. Control is positive and cushioned; not only for starting and stopping, but for positioning, tensioning, coupling, indexing and rapid cycling. Possibilities in machine construction are immense; production potentials have new peaks—through the greater flexibility of design offered by Warner **Electric** Brakes and Clutches. Send now for full technical details.



TAKE THE LEAD — LET WARNER ELECTRIC BRAKES AND CLUTCHES TAKE CONTROL

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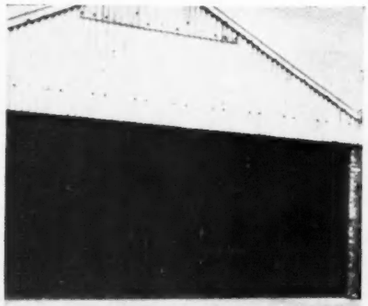
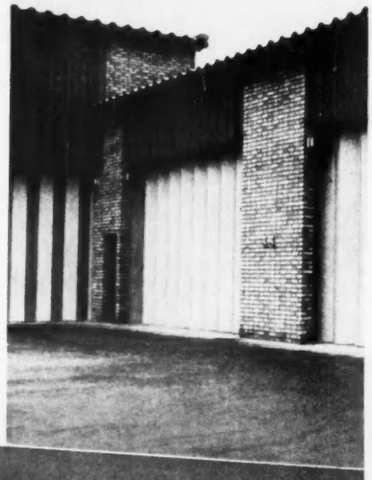
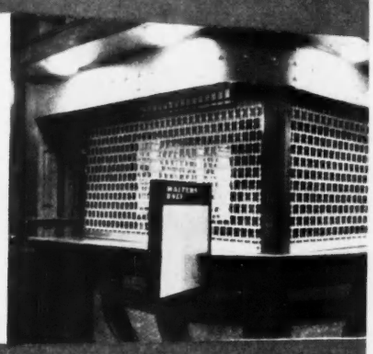
roller shutters



sliding shutter doors



rolling grilles



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(yet with vast experience)

in the field of dust recovery systems

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Today, for the convenience of customers in the Sterling Area, a subsidiary, Ambuco Limited, has been established. Ambuco offer all the advantages of the unsurpassed experience and resources of the parent concern, together with the advantages of British operation.

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For any assistance or consultation you desire in the field of dust collection or recovery, simply write or telephone our London office. An illustrated 16-page booklet is available on request:

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Super-tractor shovel shifting rocky overburden
(Photograph by courtesy of Michigan (Great Britain) Limited)

WHEREVER you see steel taking savage punishment, the chances are it will be SCW Cor-Ten from The Steel Company of Wales.

With good reason. For over the past four years SCW Cor-Ten has built up a solid reputation for sheer toughness. More and more designers and users are specifying SCW Cor-Ten where high yield strength and corrosion and abrasion resistance are of major importance.

Cor-Ten is tougher

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  Alternatively: for the same strength, a saving of $\frac{1}{3}$ of the weight is possible
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Please write to us at the address below for further information or for technical assistance in the application of SCW Cor-Ten to your products

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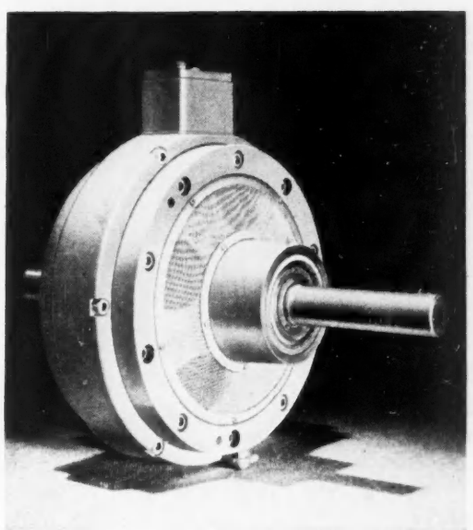
revolution in rotation

SMITHS
Magnetic Particle COUPLING



This is a positive coupling working on a new principle. It is NOT a magnetically operated clutch, and there are no plates to wear.

Driving and driven members are coupled by magnetically activated particles, giving perfectly smooth take-up and accurate control of torque. Eight standard units are made ranging from 1/3 to 200 lb/ft.

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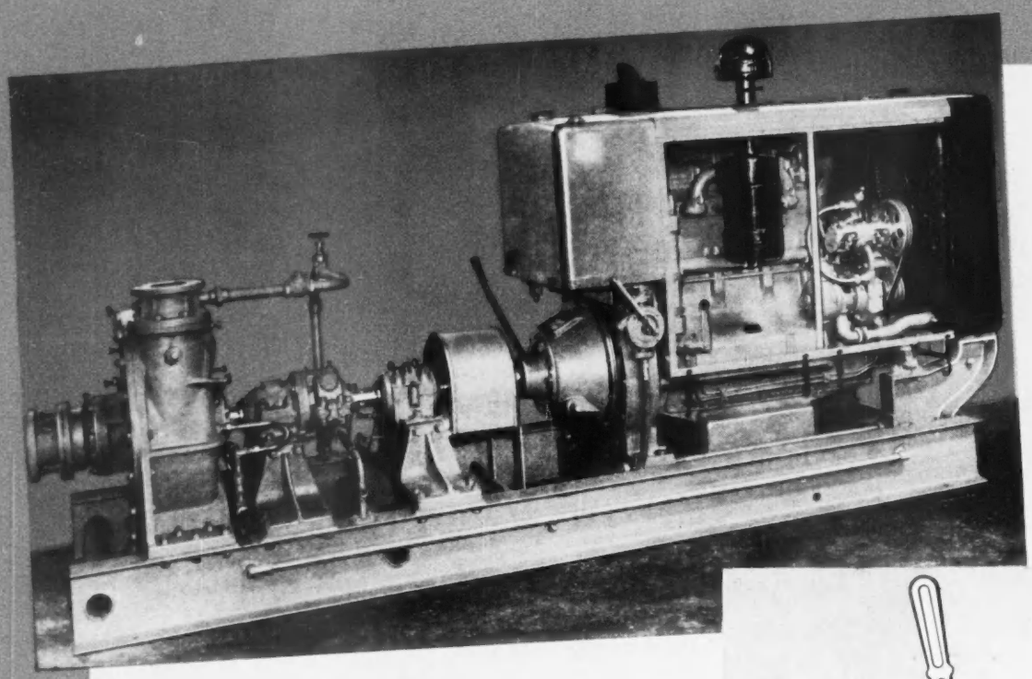

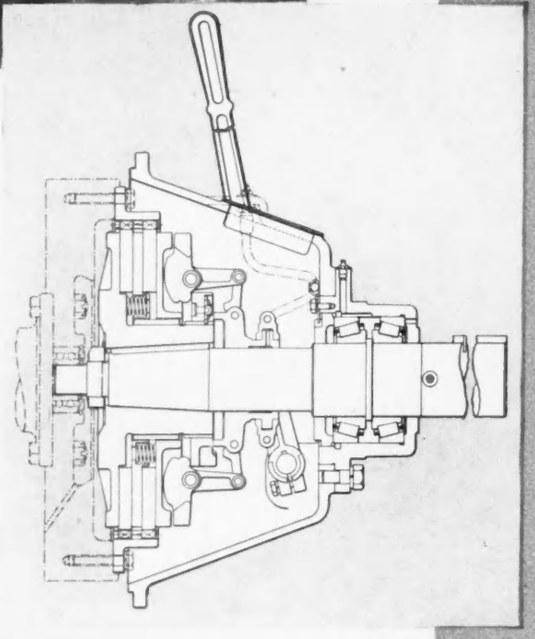

Heavy Duty Clutches

FOR INDUSTRIAL USE

ROCKFORD power take-offs and clutches are of extremely rugged construction and due to their over-centre action they run, in either the engaged or disengaged position, entirely without running thrust—which is confined to the moment of operation only.

They are made in a wide range of sizes, and in single and twin-plate form.

The top illustration shows a 4½" to 5" sand and gravel pump, made by Easton & Johnson Ltd., Taunton, England.

The diesel engine drives the pump through a Rockford 14" twin-plate clutch and power take-off (shown in the drawing).

Catalogues of Rockford and Borg & Beck clutches will be sent on request

ROCKFORD

BORG & BECK COMPANY LTD
LEAMINGTON SPA, WARWICKSHIRE
ONE OF THE AUTOMOTIVE PRODUCTS GROUP

CLUTCHES AND POWER TAKE-OFFS

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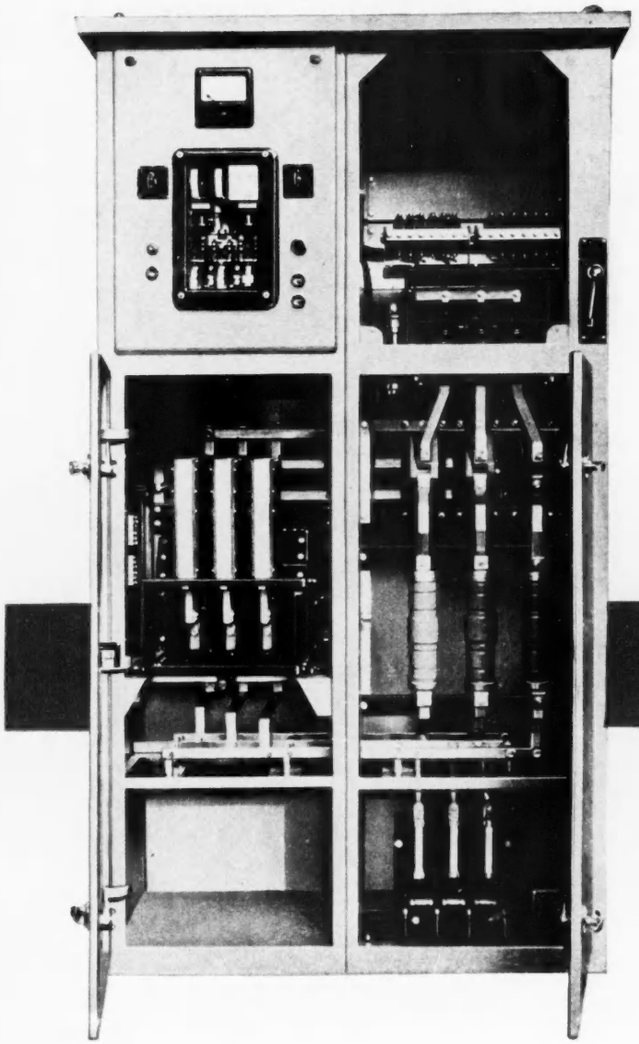
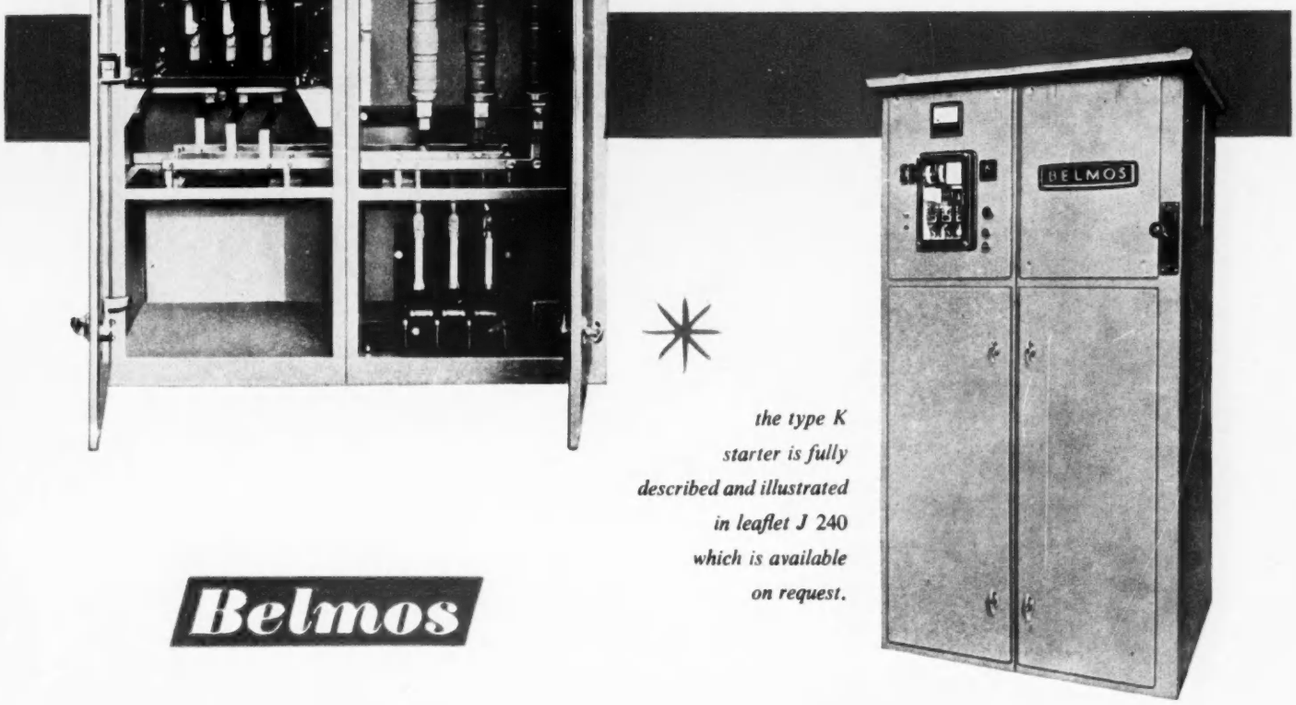
THE BELMOS 3·3 kV AIR-BREAK CONTACTOR STARTER



Rigorously tested in the Company's own research laboratory, the type K contactor starter is the latest product of the Belmos development team and continues the well-established Belmos tradition of good design and reliability. Suitable for the direct-on-line starting of 3·3 kV motors up to 600 h.p., it can be housed in a free-standing pillar or grouped with similar units to form a switchboard.

- ★ Air-break contactor rated at 150 amperes. Breaking capacity of 1,300 amperes at 3·3 kV, 0·25 power factor.
- ★ DC operating magnet supplied from 3,300/110 volt transformer within the pillar.
- ★ Reversing or Earthing isolator, mechanically and electrically interlocked, with 12 auxiliary switches, AC or DC.
- ★ Busbars designed to withstand 150 MVA for 3 seconds.
- ★ Optional earth leakage protection.
- ★ Comprehensive control arrangements, local and remote, with sequence interlocking and automatic sequence starting.
- ★ Provision for auxiliary services, such as brake protection, local lighting, etc.



the type K starter is fully described and illustrated in leaflet J 240 which is available on request.

Belmos

the Belmos company limited

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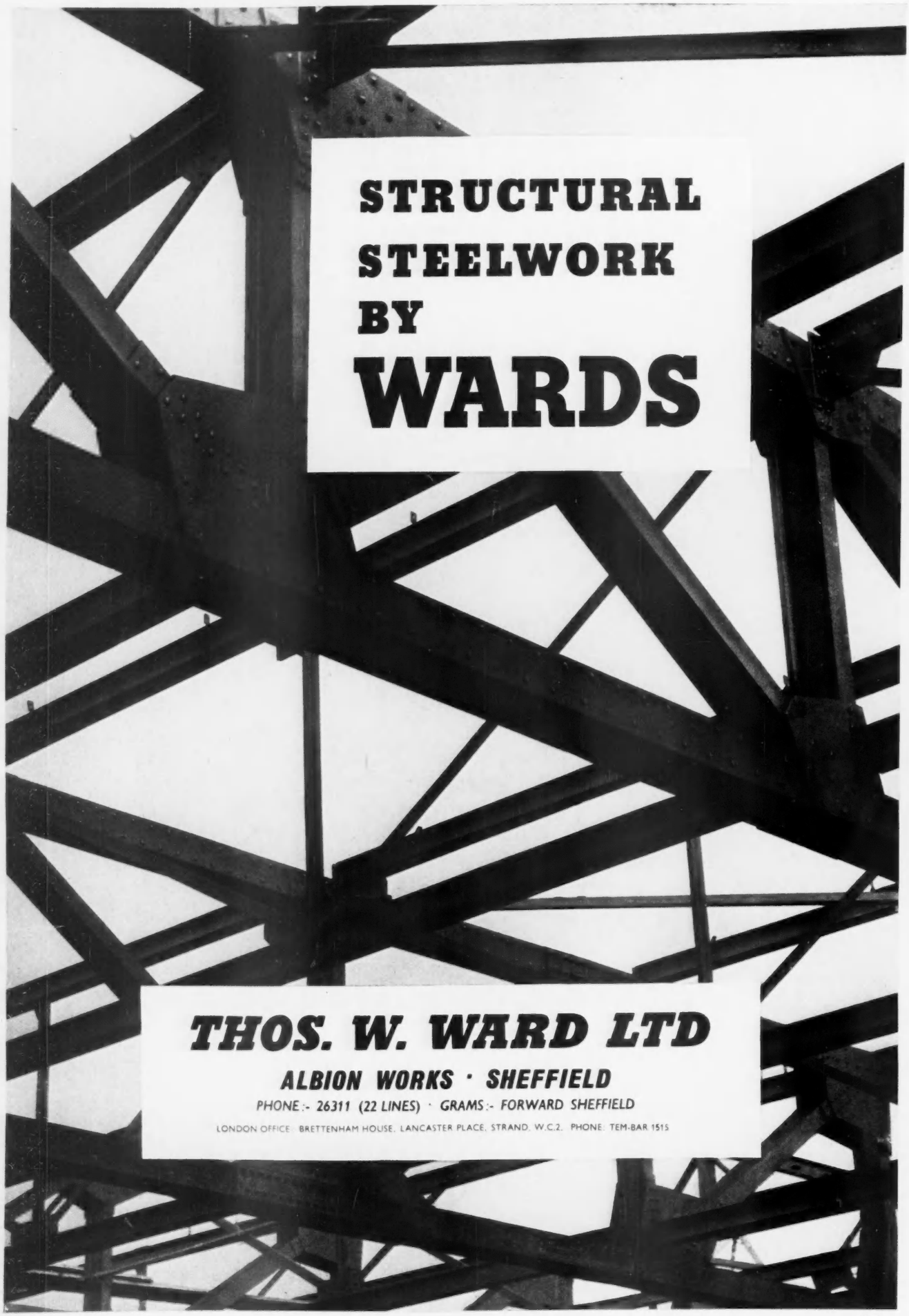

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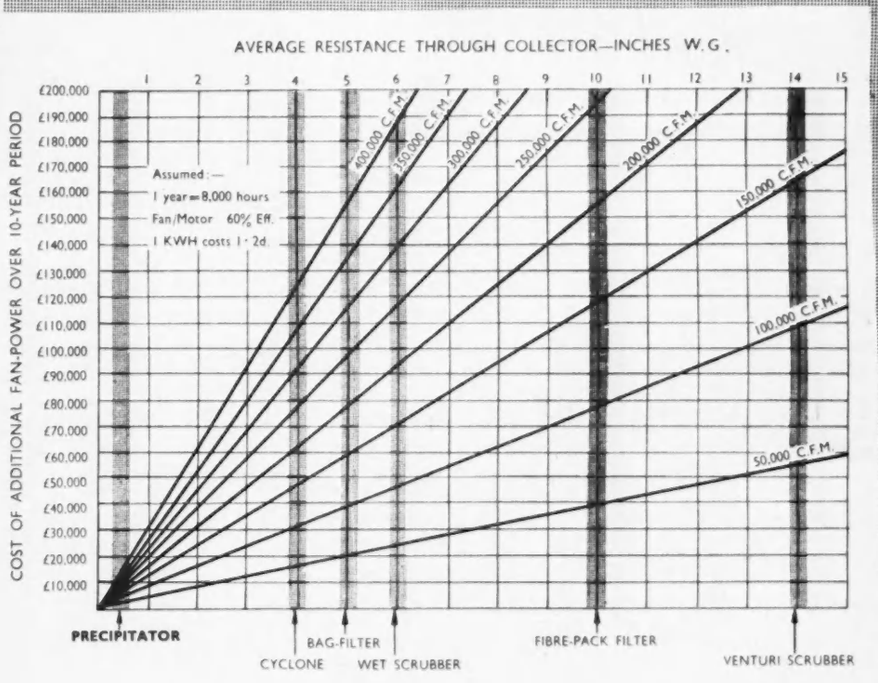
Resistance is expensive...

It's a matter of cash. You must have efficient dust collection nowadays, but some equipment costs you a fortune in extra fan power because of high resistance to gas flow. With high-efficiency electro-precipitation there is negligible resistance to gas flow—usually about ¼" w.g. Therefore the fan power needed to boost gas flow is very much less than with any other equipment capable of trapping particles smaller than 10 microns with an efficiency of over 90%. Just look at the graph to see what resistance can cost you.



Using alternative dust-collecting equipment, for a gas volume of 100,000 c.f.m. the cost of extra fan power over ten years will be anything from £30,000 to £100,000. Using an electro-precipitator, for the same volume of gas the cost over the same period is less than £5,000. High-efficiency electro-precipitation can save you thousands of pounds a year.

HIGH-EFFICIENCY ELECTRO-PRECIPITATION BY

Simon-Carves Ltd

SIMON ENGINEERING GROUP

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selfpriming
up to 26 feet vertically
for SEWAGE and SLUDGE

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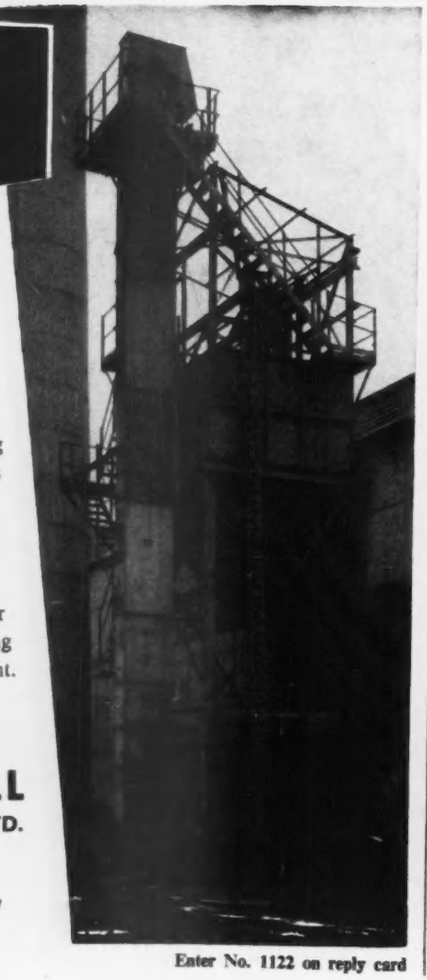

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Standard and non standard ratios available from 5 : 1 to 50 : 1.

3", 4", 5", 6" and 8" Worm Gear Centres.

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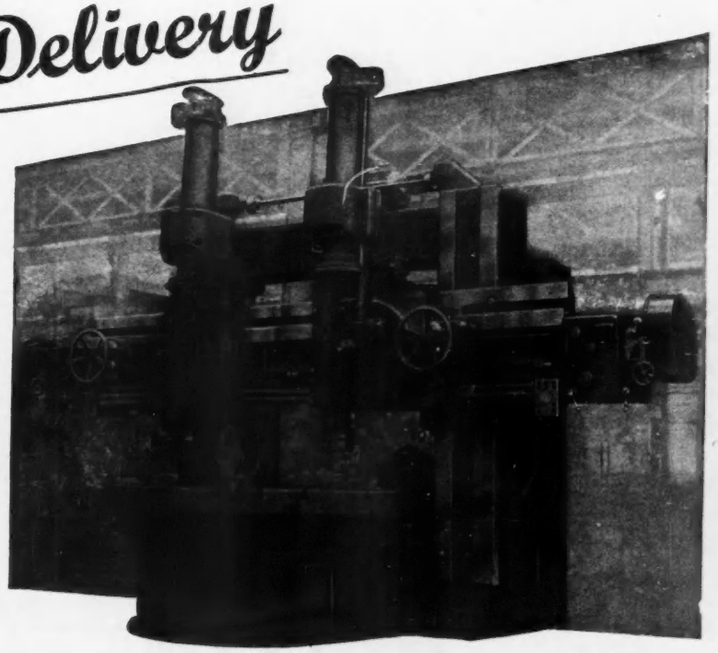

These machines are of heavy construction, each with a 30 h.p. constant-speed table driving motor and a twelve-speed gear box. Feed traverse to each saddle and its ram is by an independent variable-speed motor, and additional constant-speed motors are used for all quick traverse movements.

Duplicate control stations give complete pushbutton operation of the main motor and full selection of the ram and saddle movements, including change-over from feed to quick traverse and vice versa, the various engagements being made by magnetic clutch operation.

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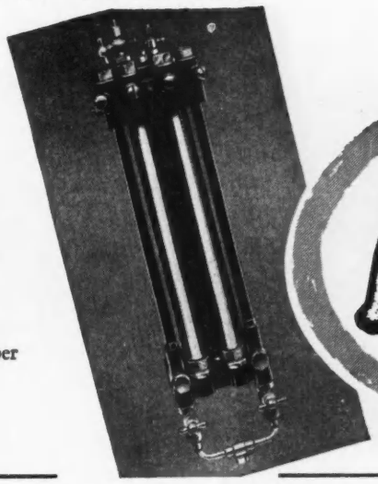
Their accuracy is within plus or minus 2 per cent.

Various models are available covering a range of 1 pint per hour to 400 gallons per hour.

Send for list No. 323.



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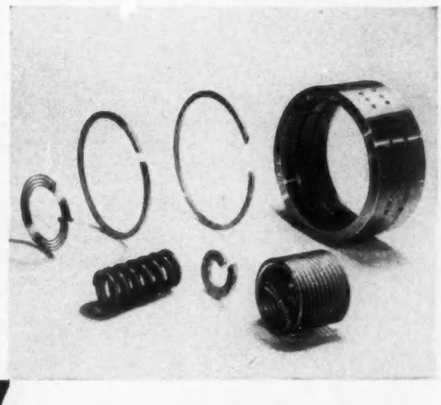

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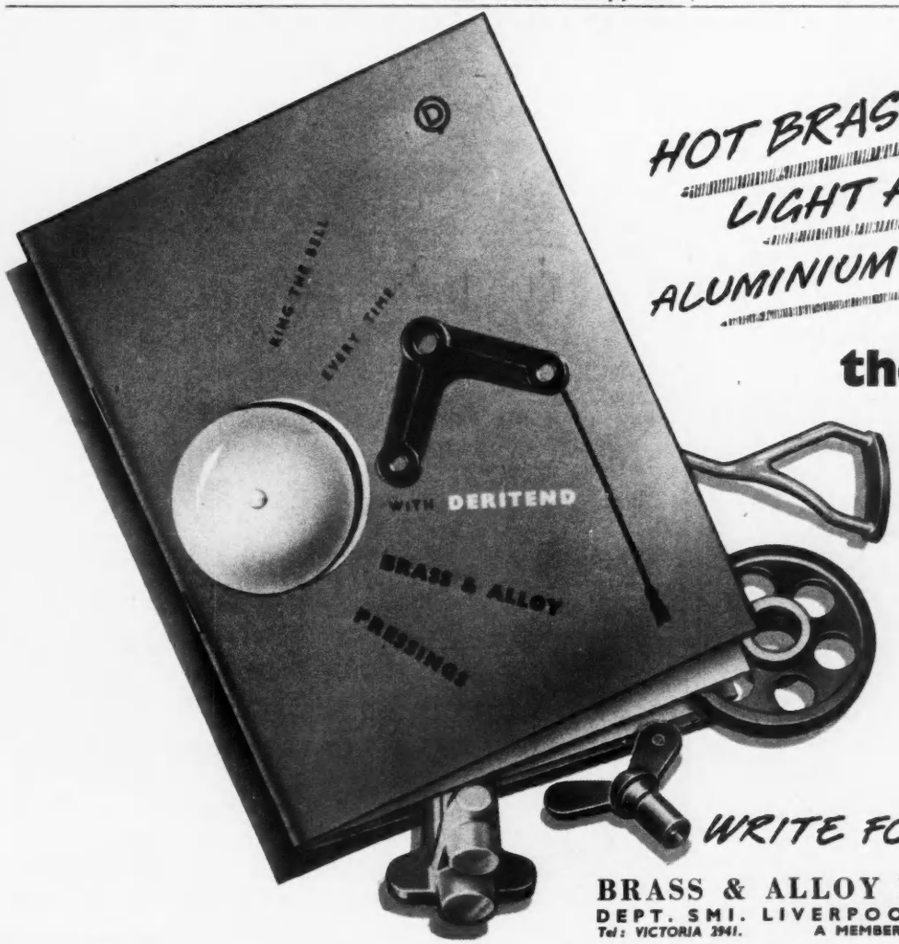

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Being automatic, they release human hands for more productive work while giving *at least* as reliable a service.

By maintaining temperatures in a sensible relationship with the conditions, they save fuel and ensure greater, more predictable, quality in the product.

On all manner of heating and cooling applications, Sarco 'S', 'B' and 'P' valves are doing their duty in improving production. Their ample hydraulic power, independence of outside energy sources, packless glands, low first cost and minimum need for maintenance recommend them to people whose job is to produce more for less.

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EG 1259

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London: 28 Victoria Street SW1 Abbey 6101-3832

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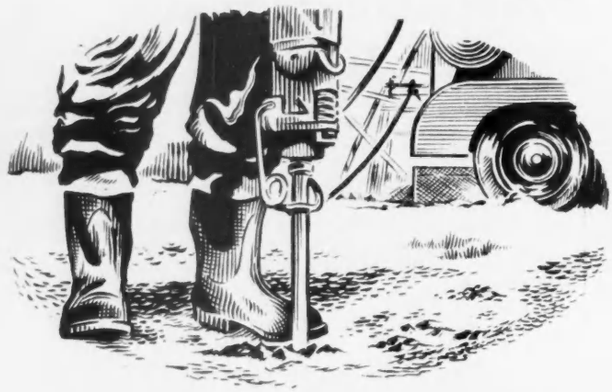
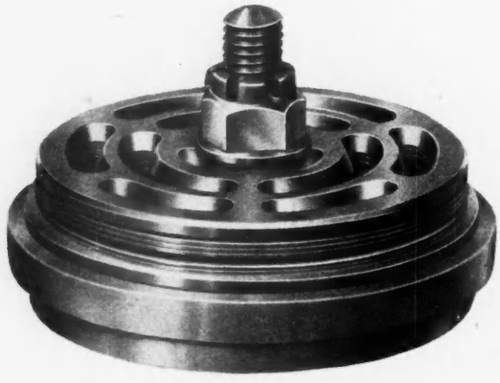
Roadmen and riveters...



and many, many more...

keep up the pressure with...



our precision valves...

EFFICIENT AND RELIABLE UNDER ALL CONDITIONS

Automatic plate and disc valves for reciprocating pumps and compressors are our particular concern. It's astonishing how many versions of these vital components we have produced in the last seventy years. Our unique experience is at your service.

THE METALLIC VALVE COMPANY LIMITED

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SPIRATUBE

VERSATILE... ECONOMICAL... ADAPTABLE...

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FLEXIBLE DUCTINGS PROVE EFFICIENCY UNDER MANY VARYING CONDITIONS

SPIRATUBE and FLEXFLYTE are recognised throughout the world as the ideal flexible ductings to deal with problems of temperature extremes, acid, alkaline and solvent fumes.
Spiratube and Flexflyte cover a diameter range from ½" to 30" and can handle conditions in a range of temperatures from minus 120° to plus 600°F.
Both Spiratube and Flexflyte have outstanding characteristics of flexibility, minimum bend radii and low weight.
Write now for illustrated literature and technical data.

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SHUNA STREET, MARYHILL, GLASGOW, N.W.

Telephone: MARyhill 3311/2 Telegrams: FLEXIDUCT, GLASGOW, N.W.

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BOLTON'S

H. C. COPPER BUSBARS

Up to 10" wide x 1" thick or 3" square drawn finish up to 12" x ½" x 16 ft. hard rolled. Extra heavy machined bars to customers' requirements. Tubular and laminated busbars.

PRE-ASSEMBLY WORK ON COPPER BUSBARS

Facilities are available in our Works for bending, sawing, drilling, slotting, and tinning, to customers' requirements.

Approximately 400 tons of H.C. Copper Busbars supplied to The Associated Ethyl Company Limited for their Chlorine Plant. The illustration shows a typical busbar, bent, drilled and slotted to customer's requirements.
Section 8" x ½".

THOMAS BOLTON & SONS LTD

Head Office: Mersey Copper Works, Widnes, Lancs. Tel: Widnes 2022
London Office and Export Sales Department:
168, Regent Street, W.1. Telephone: REGent 6427.

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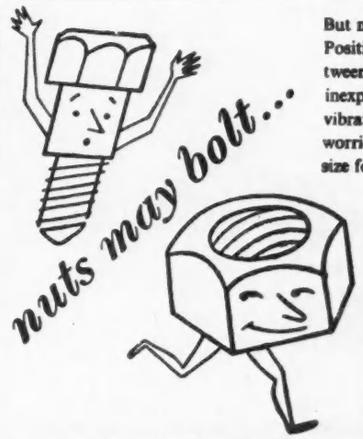

But not if you fix a Kolok Positive Lock Washer between them. Here's the inexpensive solution to vibration and slackness worries—and there is a size for every requirement.

Keep them firmly in place with

KOLOK

POSITIVE LOCK WASHERS

available in all sizes

POSITIVE LOCK WASHER CO. LTD., 45 Renfrew Street, Glasgow DOUglas 9292

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Clean Feed Water means higher boiler efficiency and lower fuel costs!

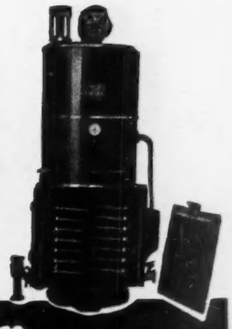
Feed water that deposits scale on boiler heating surfaces is a prime cause of overheating and subsequent tube collapse. And, remember, the majority of town water supplies, as well as sea-water, are heavy depositors of scale.

A Caird & Rayner Evaporator takes all the harm out of sea-water and provides a full supply of clean feed water to the boilers.

Not only is boiler efficiency raised and maintenance reduced appreciably, but substantial fuel savings will be seen as well.

Evaporators can be supplied to cope with feed water to any required rate. Further details will gladly be supplied on request.

EVAPORATORS AND CONDENSERS, FEED WATER HEATERS. FEED WATER FILTERS. EXHAUST STEAM OIL SEPARATORS. OIL FUEL HEATERS.



Caird & Rayner LTD

777 COMMERCIAL ROAD, LONDON E.14

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Plenty Tough!

Specialists in the manufacture of Castings in Manganese Bronze; Phosphor Bronze; Gun Metal; Brass and Aluminium.

SPECIAL ALLOYS TO SPECIFICATION

When you need tough castings . .
CHOOSE HUGHES

J. & J. HUGHES LTD., Albion Metal Work
Woodcock Street, Birmingham, 4.
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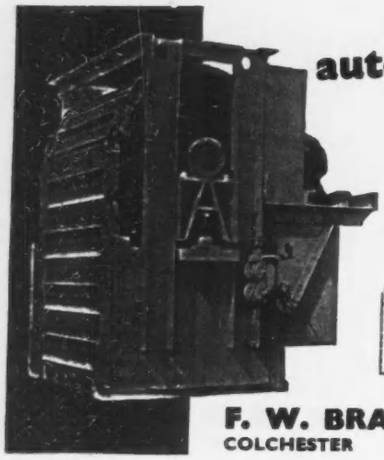

automatic screens

FOR CONDENSER COOLING
WATER - POWER STATIONS
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WATER & VACUUM

F. W. BRACKETT & CO. LTD.
COLCHESTER Telephone: 3958
P970
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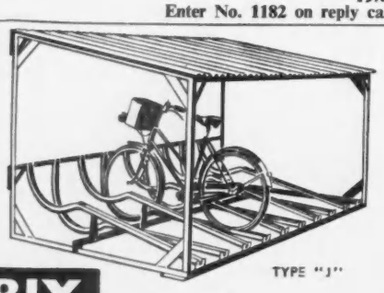
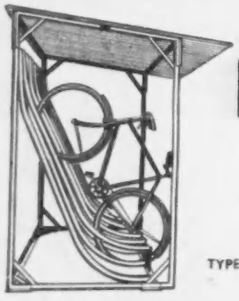
THERE



TYPE "J"

IS AN ABIX



CYCLE STAND

TO SUIT

TYPE "H"

EVERY REQUIREMENT

ABIX Cycle Stands are constructed of steel throughout, stove enamelled green. Roof sheeting is normally of galvanised corrugated sheets. If required, sheeting can be supplied in Aluminium or Asbestos.

There are 30 different types from which to choose.

Write for illustrated catalogue E/1 to :

ABIX (METAL INDUSTRIES) LIMITED
STEEL EQUIPMENT FOR OFFICE AND FACTORY
POOL ROAD, WEST MOLESEY, SURREY

Phone: MOLesey 4861/3 Grams: Abix, East Molesey
OTHER ABIX PRODUCTS: Steel Partitioning, Clothes Lockers and Adjustable Steel Shelving
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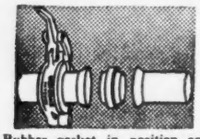
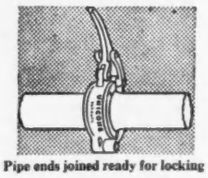
A perfect seal in a matter of seconds

For temporary pipelines 'Unicone' instantaneous joints are recommended. Comprising two parts only, they fasten with a "snap" ensuring a perfect seal in a matter of seconds.

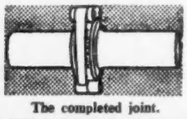
For permanent or semi-permanent pipelines 'Unicone' bolted type joints are usually employed and can be assembled far more quickly than any flexible joint giving positive anchorage.



Rubber gasket in position and joint ready to pull over.



Pipe ends joined ready for locking



The completed joint.

'UNICONE' REG'D.

Flexible Joints for Pipelines

leakproof. safe. reliable

THE UNICONE CO. LTD.
RUTHERGLEN, GLASGOW, SCOTLAND

P. G.
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THE

SIMPULSIC

'HYDRAULIC SQUEEZE'
VARIABLE CAPACITY PUMP FOR

DIFFICULT

LIQUIDS

ACIDS
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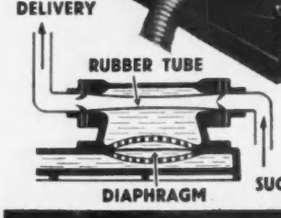
SLURRIES
AND VISCOUS
FLUIDS

CAPACITY: ZERO TO 11 G.P.M.

The Simpulsic Pump incorporates a flexible tube of chemical-resisting rubber through which the liquid to be pumped is forced by alternate pressure and suction impulses. At each end of the flexible tube there is a simple non-return valve of chemical-resisting rubber, and the end connections are of ebonite, designed to receive flexible rubber pipes. The pumped liquid never comes into contact with any metal parts and is handled throughout by chemical-resisting rubber.



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CW 4090

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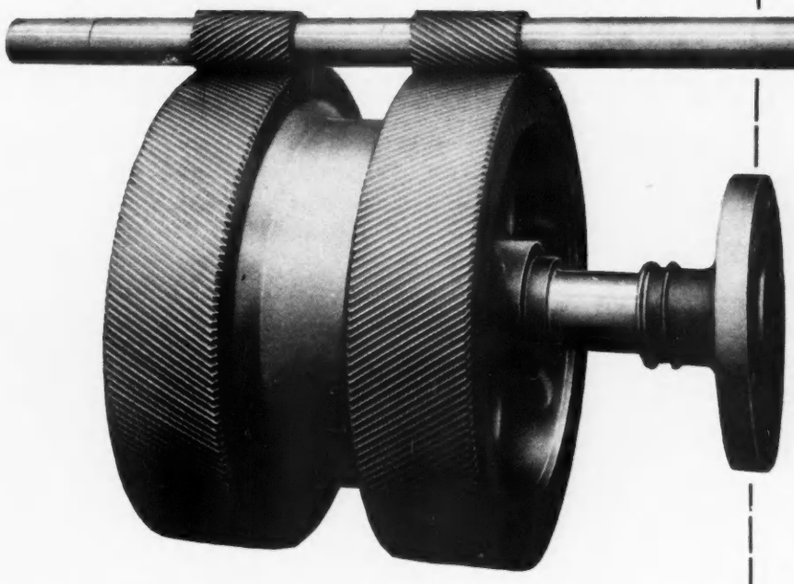
HIGH SPEED GEARS UP TO 3000 h.p.



Reid

Reid are completely equipped to produce all types of gears and drives. Gears up to 3000 h.p. and spiral bevels at 34" dia. and over give some indication of the resources at the *Linwood* factory of *Reid.*

We can now quote quick delivery of all gear units. Write, or 'phone Johnstone 861 for full details.

ENQUIRIES ARE WELCOMED FOR ALL TYPES OF GEAR CUTTING AND SPECIAL MACHINE GEAR DRIVE MACHINING.

Reid *Every Type—Every Size—Every Need.*

THE REID GEAR CO. LTD., LINWOOD, Nr. PAISLEY.

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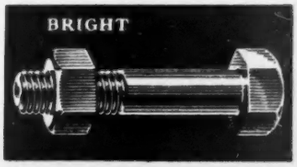
THE HOME OF **Marwin**

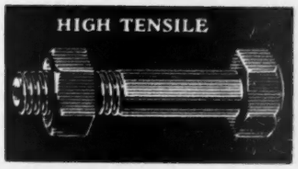
A modern factory extending over 18 acres fully equipped with an up-to-date plant for the production of the highest quality Bolts, Nuts, Studs, Sets and Special Parts in Bright Steel and in Heat Treated High Tensile Carbon and Alloy Steels for all industrial requirements. High temperature "Creep" resisting Studs, Bolts, Nuts etc. are also manufactured.

All the above are produced in sizes ranging from ¼" to 3" dia. Larger sizes supplied to special requirements.

We also supply Bright Drawn, Heat Treated Carbon and Alloy Steel Bars in Hexagons, Squares and Rounds in all sizes up to 3½" dia.

Technical details and Catalogue on request.





W. MARTIN WINN LTD.

DARLASTON, SOUTH STAFFS.

Telephone: JAMES BRIDGE 2072 (5 lines)
Telegrams: ACCURACY, DARLASTON

Enter No. 1192 on reply card

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and pro rata. 12 lines to 1 inch. There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

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Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

UNIVERSITY OF CANTERBURY, NEW ZEALAND

LECTURERS

Applications are invited for the following positions:

ASSISTANT LECTURER IN CIVIL ENGINEERING

Candidates should have the Degree of Bachelor of Engineering (Civil) of the University of New Zealand, or its equivalent. Salary: £780 by £50 to £880 per annum.

LECTURER IN CIVIL ENGINEERING

Applicants should have a Degree in Civil Engineering of a recognised University, teaching experience at a University, or have held a responsible position in a branch of Civil Engineering. Salary: £1025 by £50 to £1275 per annum.

In each case, commencing salary will be in accordance with qualifications and experience. An allowance is made towards travelling and removal expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close, in New Zealand and London, on 31st January, 1960. E8284

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, ST. JOHN STREET, LONDON, E.C.1

LECTURER AND SENIOR LECTURER

Applications are invited for appointments as LECTURER AND SENIOR LECTURER in the Department of Civil and Mechanical Engineering. Applicants should be qualified to teach in courses for the Engineering Degree and Diploma in Technology, and for Senior Lectureships should be able to make some contribution in post-graduate teaching or research. One post requires experience in bridge design in metal and concrete.

These appointments are additional to the present staff and arise from the rapid growth in the work of the College.

Salary scales: Lecturer, £1370 rising to £1550; Senior Lecturer, £1550 rising to £1750, plus in each case London Allowance of £38 rising to £51 at age 37.

Further particulars and forms of application are obtainable from the Secretary. E8173

UNIVERSITY OF CANTERBURY, NEW ZEALAND

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the above-mentioned post. Applicants should have a Degree in Mechanical Engineering of a recognised University, teaching experience at a University, or have held a responsible position in a branch of Mechanical Engineering.

The salary will be at the rate of £1025 per annum, rising by annual increments of £50 to £1275 per annum. Commencing salary will be in accordance with qualifications and experience. An allowance is made towards travelling and removal expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close, in New Zealand and London, on 31st January, 1960. E8285

UNIVERSITY OF LIVERPOOL

DEPARTMENT OF FLUID MECHANICS

ASSISTANT LECTURER OR LECTURER

Applications are invited for the post of ASSISTANT LECTURER or LECTURER in the Department of Fluid Mechanics. The initial salary will be within the range £700–£1250 per annum, according to age, qualifications and experience. Candidates should have an Honours Degree, or its equivalent, and experience in Hydraulics would be an advantage.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 4th January, 1960, by the Registrar, from whom further particulars of the conditions of appointment may be obtained. E8242

PUBLIC APPOINTMENTS

CITY OF LIVERPOOL

EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY

Principal: S. A. J. PARSONS, B.Sc. (Econ.), M.I.Mech.E., M.I.Prod.E., M.B.I.M.

SENIOR LECTURER IN INDUSTRIAL ADMINISTRATION

Applications are invited for the appointment of SENIOR LECTURER IN INDUSTRIAL ADMINISTRATION (full-time). Duties to commence as soon as possible.

Salary: (men) £1550 by £50 to £1750 per annum; (increments within the scale may be added to the commencing salary for approved industrial or professional experience or research work of an equivalent standard).

Applicants should preferably have been trained as professional engineers and hold a Degree and appropriate professional qualifications. Industrial experience (including some managerial responsibility) is essential.

Duties will include teaching industrial administration to students preparing for professional engineering institutions examinations, including work study as a specialist subject. Organising courses at post-advanced level will be encouraged. Members of staff may undertake research. The person appointed will be attached to the Department of Civil and Mechanical Engineering.

Further particulars and application form (returnable by 16th January, 1960) from H. S. Magnay, M.A., Director of Education, 14, Sir Thomas Street, Liverpool, 1.

THOMAS ALKER,
Town Clerk and
Clerk to the Local Education Authority.
(J.5961) E8299

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE, FASSETT ROAD, KINGSTON-UPON-THAMES

DEPARTMENT OF ENGINEERING

LECTURER GRADE "B"

Required as soon as possible, ASSISTANT LECTURER, Grade "B," IN MECHANICAL ENGINEERING. Candidates should have industrial experience, teaching experience desirable, and should be Graduates or possess equivalent professional qualifications. Salary, in accordance with Burnham Technical Scale, plus London Allowance.

Further particulars and application form on receipt of stamped, addressed envelope from the Principal, to be returned as soon as possible. E8293

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary: £805 at 25 to £1,095 at 34 or over, thereafter rising to maximum £1,260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. Five-day week with 4 weeks' 2 days' leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience: (i) (a) Degree or equivalent diploma in electrical and/or mechanical engineering with at least 2 years' apprenticeship, or (b) Graduate or corporate member of I.E.E. with at least 3 years' apprenticeship, or (c) Graduate or corporate member of I.Mech.E., appreciable electrical engineering experience with at least 3 years' apprenticeship, and (ii) have been employed for minimum of two years with well-established engineering concern and gained wide experience in both electrical and mechanical engineering practice. Applicants must be natural born British subjects, aged 25 to 45. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D 555/9A. E7944

PUBLIC APPOINTMENTS

CARMARTHEN MENTAL HOSPITAL MANAGEMENT COMMITTEE

ST. DAVID'S HOSPITAL AND PANTGLAS HALL

SUPERINTENDENT ENGINEER

Applications are invited for the post of SUPERINTENDENT ENGINEER from candidates holding any of the following certificates: Ministry of Transport and Civil Aviation (ex Board of Trade) First Class Certificate of Competency in Marine Engineering; Ministry of Transport and Civil Aviation Certificate of Service as First Class Engineer: City and Guilds full Technological Certificate in Plant Engineering (First Class). A sound knowledge of the principles and practices of the efficient operation and maintenance of modern institutional boiler plant and engineering services, including electrical, is essential.

Salary: £890–£1045.

An unfurnished house will be available on the estate for which a moderate rent will be charged.

The appointment is subject to the National Health Service (Superannuation) Regulations, and the successful candidate, if not a transferable officer, will be required to pass a medical examination.

Applications, stating age, qualifications, experience and present position, together with the names of three referees who can testify to professional ability, to be sent to the Secretary, St. David's Hospital, Carmarthen, not later than December 31st. E8281

NATIONAL ENGINEERING LABORATORY (D.S.I.R.)

SHIRLEY INSTITUTE, DIDSBURY, MANCHESTER

SCIENTIFIC OFFICERS/ SENIOR SCIENTIFIC OFFICERS

National Engineering Laboratory (D.S.I.R.) requires SCIENTIFIC OFFICERS/SENIOR SCIENTIFIC OFFICERS to serve initially at Shirley Institute, Didsbury, Manchester, of the British Cotton Industry Research Association joining team engaged on development of automatic spinning plant for conversion of fibres (natural and synthetic) into yarn. On completion (2 or 3 years) they will be transferred to National Engineering Laboratory at East Kilbride, Glasgow, where there is wide range of research work in field of mechanical engineering. Housing available for married staff in East Kilbride. Post (1) SO/SSO with broad engineering background. Knowledge of textile industry not essential but experience of application of automatic control systems and mechanical handling and transfer equipment required. Post (2). SO/SSO; background of applied physics or electrical engineering essential; experience of research and development of instruments for industrial use desirable. Qualifications: Ist or 2nd Class Hons. degree or equivalent; at least 3 years' post-graduate experience required for S.S.O. Salary ranges: (Men) S.O. £615–£1090. S.S.O. £1166–£1380. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1. (Quote A.543/9A.) E8261

BRITISH RAILWAYS RESEARCH DEPARTMENT

ENGINEERING DIVISION, DERBY

SCIENTIFIC OFFICER, GRADE 2

Vacancy for SCIENTIFIC OFFICER, GRADE 2. Initially to study problems connected with dynamics of trains, shocks to goods in transit, &c. Candidates should have good degree. Previous experience of research not essential.

Salary range: £665 to £985 per annum (commencing salary according to qualifications and/or experience).

Superannuation and certain travel facilities.

Medical examination.

Applications, stating age, experience, &c., to:
Director of Research (British Railways),
British Transport Commission,
222, Marylebone Road,
London, N.W.1. E8256

PUBLIC APPOINTMENTS

FYLDE WATER BOARD

ASSISTANT ENGINEERS

(1) ASSISTANT ENGINEER (MECHANICAL AND ELECTRICAL).—Salary scale: A.P.T. V (£1220–£1375).

Applicants must be Associate Members of the Institution of Mechanical Engineers and preferably also of the Institution of Electrical Engineers, or possess a Degree in Mechanical Engineering obtained at a British University, and have not less than 10 years' industrial or waterworks experience.

The work will comprise the preparation of designs and specifications for mechanical and electrical equipment for pumping, borehole, turbine and water treatment installations, and supervision of installation of same.

(2) ASSISTANT ENGINEER (STRUCTURAL).—Salary scale: A.P.T. IV (£1065–£1220).

Applicants must be Associate Members of either the Institution of Structural Engineers or the Institution of Civil Engineers. A sound knowledge and experience of modern methods of design and construction of reinforced concrete or steel structures is essential.

The Board has an extensive capital works programme in hand amounting to over £2,500,000, during the next five years. Successful applicants will, therefore, have ample opportunities for an interesting career. The Board at present supply an area of 210 square miles and a population of approximately 300,000. Amalgamation with adjoining Water Authorities will shortly increase the population supplied to nearly 500,000.

Application forms and further details of work in hand may be obtained from the undersigned.

Last date for applications, 18th January, 1960.

The appointment will be subject to the provisions of the Local Government Superannuation Acts, and Regulations thereunder, and successful applicants will be required to pass a medical examination.

FRANK LAW,
B.Sc., Tech. M.I.C.E.,
Engineer to the Board.
Sefton Street,
Blackpool. E8288

MINISTRY OF LABOUR

R.E.M.E. TECHNICAL SERVICES (WOOLWICH)

TECHNICAL ASSISTANTS, GRADE III

A first-class opportunity for entry into the Technical Branch of the Civil Service. Suitably qualified men are urgently required for training as SCALES ASSESSORS in Scales Branch, Electrical and Guided Weapons Wing, R.E.M.E. Technical Services. The job consists of assessing scales of spare parts needed to maintain and repair guided weapons systems and radar and control equipments, and entails liaison with commercial firms. Experience in repair of Service radar or control equipment at all levels essential. Training in scales work, together with equipment training, will be given.

Applicants must hold a C. and G. Intermediate Certificate in Telecommunications Engineering, with Radio II or O.N.C. in Electrical Engineering, or produce evidence of an equivalent standard of technical education or have passed a R.E.M.E. Artificer Course. The appointment carries a starting salary of £720 at 26 years, rising to £900 with good prospects of promotion. 3½ weeks' leave a year, plus other benefits and privileges.

Write, giving age, full details of qualifications and experience, to Manager (P.E. 2863), Ministry of Labour, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E8268

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

4TH ASSISTANT ENGINEER (CIVIL)

Applications invited for the above post in the Chief Civil Engineer's Department, Edinburgh. The duties would include design and inspection of works relative to the Board's fishery conservation measures. Candidates should be Graduate or Associate Members of the Institution of Civil Engineers. Salary commencing at a point within the range £840–£1040 (N.J.B. Schedule B, Class AX/DX, Grade 7), depending on experience and qualifications. Superannuation scheme.

Application forms obtainable from the Secretary, 16, Rothesay Terrace, Edinburgh, should be returned by 31st December, 1959. E8274

PUBLIC APPOINTMENTS

DEPARTMENT OF MAIN ROADS, NEW SOUTH WALES, AUSTRALIA

CIVIL ENGINEERS

Applications are invited from Graduates (or Undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges.

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road construction and maintenance either in the Metropolitan Area or the country.

Commencing salary according to qualifications and experience will be within the range £A1185 to £A1410 per annum, with annual progression, subject to technical competence to £A2095 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months.

Appointee's full fare from England to Australia will be met by the Department, subject to a three years' service guarantee bond being completed. Appointment will be subject to passing a medical examination and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent General for New South Wales, 56, Strand, London, W.C.2. When replying, please quote this paper. E8276

TOLWORTH HOSPITAL
(104 BEDS)

RED LION ROAD, SURBITON, SURREY

RESIDENT ASSISTANT ENGINEER

Applications are invited for the appointment of RESIDENT ASSISTANT ENGINEER from candidates who have completed an apprenticeship in mechanical engineering and have experience, preferably in a hospital, of the principles and practice of the efficient operation of steam and oil-fired boiler plants. Ordinary National Certificate in Mechanical Engineering desirable. Modern semi-detached house available at reasonable rental. Pension scheme in force. Salary scale: £575 by £25 (5) to £700 per annum, plus London Weighting.

Apply with details of age, qualifications and previous experience, with names of two referees, to Group Secretary, Kingston Group Hospital Management Committee, 35, Coombe Road, Kingston-upon-Thames, Surrey. E8272

DERBY No. 3 HOSPITAL MANAGEMENT COMMITTEE

THE PASTURES HOSPITAL, MICKLEOVER, DERBY

SENIOR ENGINEER

Applications are invited for the post of SENIOR ENGINEER.

Applicants should be suitably qualified and must have passed an examination in Engineering Technology.

Salary in accordance with Whitley Council Recommendations—at present £770 rising to £915 per annum.

A house will be available for a married man at a reasonable rent.

The post is subject to the National Health Service (Superannuation) Regulations and the successful candidate will be required to pass a medical examination.

Application forms, and also further details, can be obtained from the Group Secretary, to whom completed forms should be returned not later than 31st December, 1959. E8292

PUBLIC APPOINTMENTS

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS required in following localities:

LONDON AREA: MECHANICAL ENGINEER with sound knowledge of basic principles of thermo and fluid dynamics, to carry out research programme in particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage. MECHANICAL ENGINEER for research on precision gear design. MECHANICAL ENGINEER for work on propulsion problems. APPLIED MATHEMATICIAN for research of basic nature on stability of underwater vehicles; knowledge of theoretical hydrodynamics and theory of control mechanisms an advantage. APPLIED MATHEMATICIAN or THEORETICAL PHYSICIST for acoustic analysis. APPLIED MATHEMATICIAN for work with electronic computers, with special reference to research into general underwater physical problems. ELECTRONIC PHYSICISTS for data handling and analysis problems. EXPERIMENTAL PHYSICIST for research in underwater acoustics. PHYSICIST interested in operation performance. CLASSICAL PHYSICISTS.

BALDOCK: PHYSICISTS or APPLIED MATHEMATICIANS for research in Metal or Quantum Physics.

PORTSMOUTH: PHYSICISTS with experience in field of microwave techniques. ELECTRONIC/ELECTRO-MECHANICAL ENGINEERS (experience in servo-mechanisms an advantage).

HASLEMERE: ELECTRONIC ENGINEER.

PORTLAND: PHYSICISTS or APPLIED MATHEMATICIANS for research in underwater acoustics. PHYSICISTS (general). ELECTRICAL ENGINEERS with advanced electronic design experience. MECHANICAL ENGINEERS. PHYSICAL CHEMISTS.

POOLE: CHEMICAL ENGINEERS. CHEMISTS with experience in rubber technology.

ROSYTH: MECHANICAL ENGINEER with experience in welding development. ELECTRONIC PHYSICISTS.

Candidates must normally be natural born British subjects of natural born British parents, with First or Second-Class Hons. Degrees or equivalent qualifications. S.S.O.s must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men): S.S.O., £1233–£1460; S.O., £655–£1150 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those under 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.483/9A). E7844

CIVIL SERVICE COMMISSION

CIVIL, STRUCTURAL AND PUBLIC HEALTH ENGINEERS

Pensionable posts for men and women at least 25 and under 35 on 1st January, 1959 (extension for regular Forces service, Overseas Civil Service, established civil service and temporary Government service as CIVIL, STRUCTURAL, or PUBLIC HEALTH ENGINEER). Candidates must have achieved Corporate membership of an appropriate professional Institution or have passed examinations necessary for attaining such membership. Some posts require qualifications in certain subjects. Starting salary (men, London) from £830 to £1125 according to age. Scale maximum (London) £1300. Promotion prospects. Write Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S64-66/8. E8250

PUBLIC APPOINTMENTS

TRINIDAD AND TOBAGO ELECTRICITY COMMISSION

VACANCY FOR A SHIFT CHARGE ENGINEER

The Trinidad and Tobago Electricity Commission has a vacancy for a SHIFT CHARGE ENGINEER.

Applicants should have experience in the operation of modern steam turbines, water-tube boilers and diesel generators, and must have Graduate Membership of the I.E.E. or I.Mech.E., or Associate Membership of the I.Mar.E., or the Higher National Certificate in Electrical or Mechanical Engineering or Second Engineers' M.O.T. Diesel and Steam Certificate or Charge Certificate, Royal Navy.

The annual salary is £1408, rising by three annual increments to £1537. This salary includes a payment for Shift Work.

A partly-furnished house will be provided at a rent of £10 8s. 4d. per month, plus a small extra charge for heavy furniture.

An outfit allowance of £60 is paid on arrival in Trinidad.

First Class passage to Trinidad will be provided for the successful applicant, his wife and children, up to a maximum cost of four adult passages. First Class leave passages to the United Kingdom will be provided every three years.

There is a superannuation scheme similar to the C.E.G.B. and Area Board's scheme.

Information on Trinidad can be obtained from the West India Committee, 40, Norfolk Street, London, W.C.2.

Applications, giving full details of qualifications, age, experience, &c., together with copies of two recent testimonials, should be sent by Air Mail to reach the General Manager, Trinidad and Tobago Electricity Commission, P.O. Box 121, Port-of-Spain, Trinidad, W.I., by 31st January, 1960. E8298

ANGLESEY COUNTY COUNCIL

APPOINTMENT OF COUNTY WATER ENGINEER AND MANAGER

Applications are invited for the appointment of COUNTY WATER ENGINEER AND MANAGER to the Anglesey County Council Water Undertaking, the statutory area of which covers the whole of the County of Anglesey.

Applicants must be Corporate Members of the Institution of Civil Engineers and the Institution of Water Engineers. The salary will be within the scale £1862 by £70 by £65 by £65 by £65 to £2127 per annum. A house will be provided to the successful applicant free of rent and rates, valued for superannuation purposes at £100 per annum. The appointed officer will be paid an essential user's car allowance. The appointment is subject to the conditions of service recommended by the Joint Negotiating Committee for Chief Officers of Local Authorities, the passing of a medical examination and three months' notice on either side. Canvassing disqualifies.

Further particulars and form of application obtainable from the Acting Clerk of the County Council, Shire Hall, Llangefni, Anglesey. Closing date for applications, 8th January, 1960.

IDRIS DAVIES,
Acting Clerk of the County Council.

Shire Hall,
Llangefni,
Anglesey.
7th December, 1959. E8236

MARSTON GREEN MATERNITY HOSPITAL,

BERWICKS LANE, MARSTON GREEN, NEAR BIRMINGHAM

ASSISTANT ENGINEER

ASSISTANT ENGINEER required. Applicants must have completed an apprenticeship in mechanical engineering and have sound knowledge of the principles and practices of hospital boiler plant engineering and electrical services generally. Preference will be given to a candidate who has studied for the Ordinary National Certificate or its equivalent. Salary: £545, rising to £670 per annum. Post permanent and superannuable.

Detailed applications with full information relating to training and service and naming 3 referees, to Hospital Secretary within 21 days. E8279

ASSISTANT ENGINEER (MECHANICAL)

LONDON OFFICE

ASSISTANT ENGINEER (MECHANICAL) required for their London Office by Crown Agents for Oversea Governments and Administrations. Appointment normally to pensionable establishment. Commencing salary between £830 at age 25 and £1125 at age 34 or over in scale rising to £1300. Fully qualified Officers aged at least 27 years may be eligible for special increase of £75 within maximum of scale after 2 years' service. Liberal leave. Five-day week. Candidates must hold degree in Mechanical Engineering and/or be Corporate or Graduate Members of the Institution of Mechanical Engineers and have served a recognised apprenticeship or pupilage to mechanical engineering with subsequent industrial experience. Previous experience of contracts work and a knowledge of machine tools and machine shop equipment and/or refrigeration and chemical plant an advantage. Duties include the purchase of all types of mechanical industrial equipment, adjudication upon tenders and advising overseas administrations on problems connected with mechanical equipment. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2A/50852/EH. E8289

Classified Advts. continued on page 122

BOOKS and PUBLICATIONS

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"THE LOCOMOTIVES OF THE GREAT WESTERN RAILWAY"

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Describing in detail all four-coupled, miscellaneous, Sentinel and experimental locomotives.

Coloured frontispiece, 100 illustrations, full data, diagrams and boiler appendix.

Price 10/6 post free

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COMPANY MEETING

HEENAN GROUP LIMITED

RECORD TRADING RESULTS

The 57th annual general meeting of Heenan Group Limited was held on December 14 at Worcester, Mr. Charles L. Hill, the Chairman, presiding.

The following is an extract from his circulated statement:

The Group net profit, before taxation, at £521,469 is the highest ever recorded and compares with £419,481 last year. Taxation takes £262,589 against £250,167 and the net profit of the Group is £258,880 which compares with £169,314 in 1958.

During the year, W. G. Bagnall Limited was sold to W. H. Dorman & Co. Ltd., Stafford, with effect from 1st September, 1958, and accordingly no profits from this former subsidiary are included in the Accounts.

The downward trend in the order position, to which I referred in my last Statement, continued during the first half of the year but thereafter there was a marked recovery and the year ended with a balance of orders of £3,600,000 compared with last year's figure for the present Group companies of £4,000,000.

The Group's cash and marketable investments have increased considerably. This complete change in the position in the short space of a year after a long period of scarcity of funds is due to many factors and it is fortuitous that they have occurred at the same time. Your Board is taking steps to acquire other engineering or allied businesses and so spread the interests of the Group in engineering and negotiations are proceeding.

REVIEW OF OPERATING COMPANIES

Heenan & Froude Limited. In the Engine Test Plant Section the demand for special plant has absorbed a high proportion of design capacity.

The record sales last year in the Eddy-current Coupling Section have been maintained and business in the conveyor field has continued satisfactorily. In the Electronic Engineering Section sales continued to advance and an 80 per cent increase over the previous year was recorded.

In the Industrial Cooler Section the number of customers supplied increased slightly but the total sales value was down due to a falling-off in demand for quantity supply of Coolers for large plant installations.

There has been a slight improvement in sales of Automatic Wire and Strip Forming Machines.

The Municipal Engineering Division has had a good year, the value of contracts received being more than double that for the previous financial year.

Fielding & Platt Limited at the end of the year had orders on the books slightly in excess of the previous year, but again as before, a substantial proportion of these are for long-term delivery. However, enquiries remain active, and it is thought that a number of capital equipment schemes under negotiation are likely to mature during the next few months.

Production and sales of Malleable Iron and Grey Iron Castings by **Court Works Limited** were maintained at around the levels of the previous year with an unchanged balance of orders in hand.

Morton Machine Co. Ltd. had a satisfactory year's trading, the output of mixing machinery to the Food Trade being the highest for many years. Export sales were world-wide and represented over 20 per cent of total production.

IWEL Engineering Limited traded at a reduced profit due to the lower level of orders received during the year. Since the close of the financial year substantial overseas orders for IWEL equipment have been received from Jugoslavia and South Africa.

The profits of **Associated Locomotive Equipment Limited** represented a reasonable return on capital but were well below the record achieved last year. Efforts are being made to broaden this subsidiary's activities outside the railway field.

The report was adopted and the total distribution of 15 per cent (10 per cent last year) was approved.

PUBLIC APPOINTMENTS

WOLVERHAMPTON CORPORATION WATER UNDERTAKING

ENGINEERING ASSISTANT

ENGINEERING ASSISTANT for new works design, Grad.I.C.E. or University Degree, with waterworks experience. £785–£1070 (A.P.T. Special), starting figure according to experience. N.J.C. service conditions, post pensionable, medical examination, house to rent.

Applications, naming two referees, to Water Engineer and Manager, Water Offices, 37, Merridale Road, Wolverhampton, by 29th December, 1959.

E8245

TENDERS

MINISTRY OF TRANSPORT

MEDWAY TOWNS MOTOR ROAD

CONTRACT NO. 1

MEDWAY BRIDGE

TENDERS are invited from Contractors with considerable experience of major bridgeworks for the CONSTRUCTION of the MEDWAY BRIDGE across the river Medway near Rochester, and of SHAKE HOLE and NEW CUXTON ROAD BRIDGES over the railway line from Sole Street to Rochester on the west bank of the river Medway. Tenderers will be required to submit with their Tenders particulars of major bridgeworks which they have previously carried out.

The Medway Bridge comprises 17 Viaduct Spans of 100ft. to 135ft. and three River Spans of 313ft., 500ft., and 313ft. The bridge carries a two-lane dual carriageway motor road with hard shoulders, and also cycle tracks and footways. The roadway is approximately 116ft. above water level.

The viaducts consist of reinforced concrete deck slabs cast on top of precast, prestressed concrete beams which are supported by reinforced concrete portal piers founded on piles or on spread footings. The foundations for the two main river piers which support the river spans are founded on hard chalk reached by open excavation inside steel cofferdams. The piers are hollow shafts of reinforced concrete or steel.

Alternative Tenders are invited based on prestressed concrete and welded steel designs of the superstructure for the three river spans.

Contract documents and drawings can be obtained from the Consulting Engineers, Messrs. Freeman, Fox and Partners, at 68, Victoria Street, Westminster, S.W.1, on payment of a deposit of £50 by cheque or Payable Order made payable to the Minister of Transport. The deposit will be refunded if a bona fide tender is submitted and not subsequently withdrawn.

Contract documents and drawings may be inspected by appointment at the office of the Consulting Engineers before payment of the deposit.

Tenders must be submitted in a sealed, registered envelope marked "Tender for Medway Bridge," addressed to the Assistant Secretary, Highways Management and Services Division, Ministry of Transport, 21-37, Hereford Road, London, W.2, to arrive not later than 4 p.m. on Tuesday, 8th March, 1960.

The Minister does not bind himself to accept the lowest or any Tender. H. GILLENDER,

E8196 An Asisstant Secretary.

WELSH COLLEGE OF ADVANCED TECHNOLOGY, CATHAYS PARK, CARDIFF

SUPPLY OF EQUIPMENT FOR A HIGH VOLTAGE LABORATORY

Fixed Price TENDERS are invited for the SUPPLY of EQUIPMENT for a HIGH VOLTAGE LABORATORY. The equipment is to include 300kV, 50 c/s Testing Transformer ; 330kV, Impulse Generator ; Control Units ; Measuring Sphere Gap ; Resistance and Capacitance Potential Dividers.

Tenders will not be considered unless enclosed in the envelope provided, endorsed "Welsh College of Advanced Technology—Laboratory Equipment," addressed to the undersigned at the City Hall, Cardiff, and sent by Registered Post, so as to be received not later than 16th January, 1960.

The envelope must not bear the name of, or any mark indicating the identity of the Tenderer.

The Governors do not bind themselves to accept the lowest or any Tender.

Further details and form of Tender are available on application to the Principal, at the College.

ROBERT E. PRESSWOOD,
Clerk to the Governing Body.

City Hall,
Cardiff. E8165

INDIA SUPPLY MISSION

The Office of the India Supply Mission, Washington, 2536, Massachusetts Avenue, N.W. Washington, D.C., U.S.A., invites TENDERS for the following :

(a) TENDER ENQUIRY NO. SE.66.
For the SUPPLY of :
(i) Grab Type Dredgers, 12 cu. ft.... ... 8 Nos.
(ii) Cement Grouting Pumps ... ... 5 Nos.
(iii) 3-ton—50/65ft. Drop Hammer Driving Plant... ... ... 1 No.
(iv) Deflectometers for Bridge Deflection 7 Nos.

(b) TENDER ENQUIRY NO. SE.127.
For the SUPPLY of :
10-ton Mobile Crane ... ... 1 No.

(c) TENDER ENQUIRY NO. SE.129.
10-ton Self-propelled Diesel Hoists... 3 Nos.

Specifications, Tenders, &c., can be obtained from the Co-ordination Branch, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, at a cost of 14 shillings and threepence per tender set.

Tenders are to be returned direct to the India Supply Mission, Washington, U.S.A., so as to reach them by (a) 20th January, (b) 3rd February, (c) 9th February, 1960.

Specimen copies of the above enquiries can be seen at Engineering Branch, India Store Department, address as above under references (a) S.3849/59, (b) S.3829/59, (c) S.3770/59/ENG.2. E8260

TENDERS

SHEFFIELD CORPORATION WATERWORKS

YORKSHIRE DERWENT SCHEME

TENDERS FOR HIGH-LIFT PUMPS

TENDERS are invited from Pump Manufacturers for the SUPPLY and INSTALLATION of the WATER PUMPS and MOTORS for the three high-lift pumping stations proposed within the Yorkshire Derwent scheme of water supply. Each station will be capable of raising over 10 m.g.d. through heads of the order of 200ft.

Persons wishing to Tender should apply for the necessary documents, which will include instructions regarding the method and date of submission, to the General Manager and Engineer, Water Department Town Hall, Sheffield, 1. E8267

EDUCATIONAL

COLLEGE OF AERONAUTICS

A SHORT COURSE ON
AIRCRAFT GAS TURBINE THEORY AND DESIGN

will be held at the College from Monday, 29th February to Friday, 18th March, 1960.

The course will deal mainly with performance, systems, turbo-machine aerodynamics and related design topics, but will include some experimental work on engines.

Fees for the course are £70 inclusive of full board and residence.

Further details and copies of the syllabus may be obtained on application to the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

E8286 E

A.M.I.MECH.E., B.Sc., City and Guilds, etc. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent successes. 148-page prospectus free, on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A. JOHNSON AND CO. (LONDON), LTD.,

require the services of a qualified ENGINEER for their "Votator" Department, which is expanding rapidly.

The work involves process and sales engineering and applicants must be prepared to travel mainly in the U.K., but also abroad.

We are looking for a man in the age group 25 to 35, who has a University Degree in Mechanical or Chemical Engineering or Chemistry, or similar professional qualifications. He must also have had at least five years' practical experience in the food industries. Knowledge of German and/or French an advantage.

The position, which is pensionable, offers considerable scope for a man who is willing to work hard to make a good future for himself in an organisation with world-wide ramifications.

Reply, giving full details, to Villiers House, Strand, London, W.C.2.

E8300 A

APPLICATIONS ARE INVITED from ambitious and resourceful men to fill the position of TECHNICAL ASSISTANT to the Sales Manager of Electric Lamp Machinery Manufacturers near London. A permanent, progressive and interesting job is offered to the right person, who must possess a sound engineering and commercial background in the trade.—Applications, with full particulars of education, experience and salary required to BOX No. E171, "The Engineer." A

ASSISTANT MECHANICAL ENGINEER required for plant operation and maintenance on Nauru and Ocean Island, Central Pacific. Qualifications up to G.I.Mech.E. or equivalent. Under 30 years of age. Salary, £1025 p.a. Australian currency plus qualification allowance up to £50, also child and other allowances where applicable. Free board for single man or allowance in lieu thereof of £282 for married employee. Furnished accommodation provided. No income tax payable on Island earnings. Free passages to and from U.K. and, on interim leave, free passages to and from Australia or New Zealand. Climate healthy with good living conditions. Terms of service 3½ years with intermediate leave after 21 months.—Apply, in writing to The British Phosphate Commissioners, 2, Grosvenor Gardens, London, S.W.1. E8259 A

ASSISTANT OUTSIDE ENGINEERS wanted (age 23–32). Civil or Constructional Engineering experience essential. Technical qualifications desirable. Good prospects. Permanent posts. Salary according to experience, age and qualifications. Generous out living allowances and leave. Pension, Insurance and Bonus Schemes.—Apply in writing with particulars of education, &c., to The Personnel Officer, Woodall-Duckham Construction Company, Limited, 63-77, Brompton Road, London, S.W.3. E8273 A

BP invites applications from GRADUATES, aged 23–26 years, with an honours degree in Petroleum Engineering, Engineering or Physics for employment as ASSISTANT PRODUCTION ENGINEERS in Trinidad in the first instance. Duties will consist of assisting in all aspects of field production work, including well control, artificial lift, gas control, oil collection and well servicing. National Service obligations must have been fulfilled.—Write, stating age and full details of qualifications and experience, quoting F.574A, to Box 3214, c/o 191, Gresham House, E.C.2. E8254 A

SITUATIONS VACANT

BP requires PETROLEUM ENGINEERS for overseas service in its Exploration Department. Applicants, aged between 20–27, must possess an Honours Degree in Physics, Mechanical Engineering or Petroleum Engineering. Previous oilfield experience would be an advantage. Salary according to age, qualifications and experience. National Service obligations must have been fulfilled.—Write, stating age and full details of qualifications and experience, quoting F.579, to Box 3209, c/o 191, Gresham House, E.C.2. E8255 A

BP has vacancies for young MECHANICAL ENGINEERS for service with its Overseas Exploration Drilling Operations. Applicants up to 30 years old must have O.N.C. in Mechanical Engineering or equivalent and have served a five year apprenticeship with a diesel engine manufacturer with experience in fitting, turning and preferably some outside erection work with subsequent experience in operating and maintaining diesel engines. Experience of steam pumps, engines, boilers and refrigeration advantageous. Attractive salary plus generous allowance in local currency, free passages out and home, free medical attention, good leave arrangements. Kit allowance. Pension Scheme.—Write, giving full particulars, quoting F.582, to BOX 3217, c/o 191, Gresham House, E.C.2. E8282 A

CHIEF ENGINEER required for progressive medium-sized Company specialising in aircraft and other light engineering equipment. Excellent prospects for fully qualified man with the right experience. —BOX No. E2659, "The Engineer." A

COLONY OF MAURITIUS

CIVIL ENGINEER wanted (by Messrs. Boulle Lagesse Schaub, Ltd., Architects), to act as Chief Inspector on large Governmental housing scheme and advise on reinforced concrete structures.

Three years contract (with good prospects for extension) to start beginning 1960. Salary about £1200 per annum, plus return air fare to U.K. House, car, with running and travelling allowances.

Candidates should preferably speak French and have had experience in housing.

Applications, giving age, education, qualifications, detailed experience, and names of two referees, should reach BOX No. 09X3, Wm. Porteous and Co., Glasgow, before 31st December, 1959.

E8266 A

CRANE DESIGNER DRAUGHTSMAN required in the West Riding, Yorkshire, with sound knowledge of Overhead Travelling Cranes. Age 30 to 40 years. The work is interesting and of varying nature, and the future prospects are excellent. House provided if necessary. Give details of experience and salary required.—BOX No. E8142, "The Engineer." A

DESIGN AND LABORATORY ASSISTANTS

required for Research and Development work. Should be H.N.C. standard and have electrical/mechanical experience. Interesting work and good prospects for the right men.

Write fully, stating, age, education and experience to :

The Personnel Manager,
J. Stone & Co. (Deptford), Ltd.,
Arklow Road, S.E.14.

E8271 A

DRAUGHTSMAN MECHANICAL (SENIOR) required by the British Drug Houses, Ltd., for layout and special machine development in their chemical laboratories. H.N.C. or equivalent preferred. Five-day week, Canteen, Sports Club, Pension and Profit Sharing Schemes.—Apply in writing, stating age and educational attainments to the Staff Manager, Graham Street, City Road, N.1. E8231 A

ENGINEER for work in connection with site investigations and soil mechanics laboratory required immediately by Consulting Engineers, F. R. Bullen and Partners, Dacre House, Dean Farrar Street, London, S.W.1. E8233 A

HENRY WIGGIN AND COMPANY, LIMITED, HEREFORD,

are expanding their high-temperature creep testing facilities, initially at Birmingham and later at Hereford, and require a Graduate ENGINEER, PHYSICIST or METALLURGIST to take responsibility for the commissioning and operation of the new equipment. Previous experience of high-temperature mechanical testing would be an advantage. Applicants are invited to submit details of their qualifications and experience to the Chief Metallurgist, Henry Wiggin and Company Limited, Holmer Road, Hereford. E8247 A

GRADUATES OR EQUIVALENTS REQUIRED for new appointments in the following fields :

(1) Applied research and development of press working processes, cold extrusion and other new techniques for the forming of metals.
(2) Applied research on machining processes ; initially work will be concerned with the appraisal of new machining developments or studies of machining costs on a comprehensive scale.
(3) Research, design and development of a variety of mechanical engineering equipment, including special machine tools, mechanisms, test rigs, &c.

Successful candidates will be expected to take complete responsibility for projects from conception to completion. Capacity for creative thinking and initiative are important. The conditions of employment are attractive and there are excellent prospects for advancement. Superannuation scheme. Removal expenses paid. Send full details in confidence to the Secretary, Production Engineering Research Association, Melton Mowbray, Leics. E8226 A

SITUATIONS VACANT

ENGINEERS
are required at
A.E.R.E., HARWELL

to be responsible ON SHIFT for the operation of high flux experimental reactors. These posts offer :

First-class training for young engineers with good academic qualifications who wish to enter the reactor field.

An opportunity of studying at first hand the principles of design and operation of high flux reactors.

Posts also exist giving interesting careers for men with good watch-keeping experience on large main and auxiliary machinery.

Applicants should be Corporate Members of a Senior Engineering Institution or have equivalent qualifications.

Salary : £845–£1800 per annum, according to qualifications and experience.

Housing and Superannuation schemes.

Please send a POST CARD for details to Group Recruitment Officer (1516/25), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks. E8244 A

MONSANTO CHEMICALS, LIMITED,
have a vacancy at
Newport Works, Monmouthshire,
MECHANICAL ENGINEER

to assist in investigational work involving Maintenance Engineering operations and to liaise effectively with Production and Maintenance supervision. Applicant should possess a University degree or equivalent qualification with preferably 2–3 years Industrial Engineering experience.

This post offers good starting salary and careeer prospects ; non-contributory pension scheme.

Please send written applications giving details of age, qualifications and experience to DL.116, Personnel Department, Monsanto Chemicals, Limited, Monsanto House, 10-18, Victoria Street, London, S.W.1.

E8265 A

PLANT ENGINEER required. To be responsible for all maintenance services of fruit and vegetable processing factory. This progressive position demands a man of vigour and energy, within the age range 25–35, who has had a sound, practical and technical training to H.N.C. level. Experience of food processing and packaging machinery an important advantage.—Apply, giving full details of age, experience, qualifications, &c., to Personnel Manager, ESKIMO FOODS LIMITED, Pelham Road, Cleethorpes. E8168 A

POLLARD BEARINGS LIMITED
FERRYBRIDGE, KNOTTINGLEY, YORKSHIRE

require the services of a qualified METALLURGIST to introduce and control materials quality department.

Please give fullest possible details of education and past commercial experience, together with an indication of salary required.

Address replies to General Manager, marked "Confidential."

E8302 A

RICHARD THOMAS & BALDWINS, LIMITED,

have the following vacancies
at their
Central Engineering Department,
Spencer Works, Llanwern, Nr. Newport, Mon.

1. TECHNICAL REGISTRAR
(MALE)

Duties include the registering and handling of drawings and technical data, recording and issuing of prints, and ordering of Drawing Office and Print Room materials. Will be responsible for a small staff assisting in these duties.

Steelworks experience and knowledge of office routine are desirable.

2. TRACERS
(SENIOR AND JUNIOR)

For the senior posts applicants should be competent Tracers with at least four years experience. The ability to print (freehand) efficiently is essential and a technical qualification would be an advantage.

Applicants for the junior posts must be experienced in producing ink tracings.

Salary scales commensurate with qualifications and experience. Contributory Staff Pension and Life Assurance Schemes.

Application form can be obtained by writing to :

General Manager—Engineering,
Richard Thomas & Baldwins, Limited,
"Coed Parc," 42, Park Street, Bridgend, Glam.

E8270 A

PRODUCTION PLANNING ENGINEER required by medium-sized Engineering Works in the Midlands. Applicants should be between 25 and 35 years of age and have approved engineering background with H.N.C. in Mechanical or Production Engineering. Experience of Production Planning is not essential, but some Work Study experience would be an advantage. The position is directly responsible to the Works Manager, and calls immediately for the planning of all work through the factory, and possibly later for the investigation of processes with a view to Method Improvement.—Applications, giving age, full details of education, experience, qualifications and present salary, should be addressed to the Works Manager, Ewart Chainbelt Co., Ltd., Derby. E8290 A

SITUATIONS VACANT

PROJECT ENGINEER
required for
MECHANICAL HANDLING WEIGHER DIVISION

of old-established and go-ahead company.

Basic qualifications are H.N.C. in mechanical engineering, experience in belt conveyor design, and in commercial contact with customers.

The duties involve visits to customers, the preparation of quotations, negotiation of orders, and piloting of contracts to completion.

There is a contributory pension scheme, with life assurance.

Applications will be considered only from those who possess these qualifications, supported by enthusiasm, and who will work as one of a team.

Write, giving fullest information, including details of present earnings, to :

The Commercial Director,
SAML. DENISON & SON LTD.,
HUNSLET FOUNDRY,
LEEDS, 10.

E8257 A

SALES ENGINEER

required by well-established company in the London area.

Applicants should be 30 to 40 years of age and have professional qualifications in chemical or mechanical engineering.

Experience of selling to the food and chemical industries and established connections essential.

A good salary will be paid to the right man.

Pension scheme is available.

Reply, giving full particulars, to BOX No. E8301, "The Engineer,"

A

SENIOR DESIGN DRAUGHTSMEN, familiar with small mechanisms, etc., required by progressive and expanding Company situated approximately 20 minutes from Waterloo. The positions offered are permanent and provide excellent prospects for versatile men who seek interesting work in a new field.—BOX No. E169, "The Engineer." A

SENIOR MECHANICAL DRAUGHTSMEN

Senior Mechanical Draughtsmen required for interesting work on Machinery and Plant layout and design in large developing man-made fibres production plant. Experience in Chemical industry an advantage. Five-day week. Good Pension Scheme. Salary according to qualifications and experience.—Applications should state age, qualifications, experience in sequence, and be addressed to Personnel Manager, BRITISH ENKA, LTD., AINTREE, LIVERPOOL.

E8258 A

SENIOR PROJECT DRAUGHTSMAN required for Mechanical Handling Plants. Applicants must be able to lay out schemes. Experience in Estimating an advantage but not essential. Good prospects.—W. W. Brown & Partners, Ltd., 72, Newman Street, London, W.1. E2660 A

SITE SAFETY OFFICER required prior to January 1st, 1960, for Uskmouth "B" Power Station Site near Newport, Mon. Adequate experience of Public Works and Power Station construction, building and scaffolding is essential with a sound knowledge of the Factory Acts 1937–1948. Salary commensurate with experience.—Applications should be sent to Braithwaite and Co. Structural, Ltd., Uskmouth "B" Power Station, West Nash, Newport, Mon., so as to arrive not later than 30th December, 1959. E8278 A

STRUCTURAL DESIGNER required with experience in plate work, pressure vessels, tanks and general construction works. Superannuation Scheme. Canteen facilities. Five-day week.—Apply in writing, stating age, experience and salary required to Personnel Manager, Mechans Limited, 1071, South Street, Glasgow, W.4. E2658 A

STRUCTURAL ENGINEERING DESIGNER required in London office of Consulting Engineers. Should have a University Degree in Engineering or the Associate Membership of either the Institutions of Civil or Structural Engineers and must have had at least one year's experience on the design of structural steelwork. Some experience on reinforced concrete design would also be an advantage. Salary according to experience. Five-day week. Pension scheme. Luncheon vouchers. Apply, stating age and experience.—BOX No. E8152, "The Engineer." A

THE GLACIER METAL COMPANY invites applications for two posts of SENIOR APPLICATIONS ENGINEER. The Company has recently established within its Research and Development Organisation a new department whose function is to use the latest research knowledge in advising customers on all aspects of bearing design. Two appointments are now to be made, in each of which the Engineer will be responsible to the Manager of the new department and will have initially one assistant. The work entails a wide and interesting range of contacts in the engineering industry. As Technology advances new mechanical designs raise new bearing problems and new bearing designs make possible innovations in the design of machinery. A senior Applications Engineer is responsible both for devising solutions to bearing problems raised with the Company by its customers and for searching out areas where such innovations are practical. Applicants should have a good Honours Degree in Engineering, Physics of Mathematics, together with a completed apprenticeship. Experience in Research, Design or Development work would be useful. Salary Range : £1350 to £1830 per annum. —Applications should be sent to Personnel Director (Ref.: SAE), The Glacier Metal Company, Ealing Road, Alperton, Wembley, Middx. E8291 A

UNILEVER LIMITED invite applications for appointments as MECHANICAL ENGINEERING DRAUGHTSMEN/DESIGNERS in the London Office of their Associated Company, T. Wall & Sons (Ice Cream), Ltd. Qualifications equivalent to Higher National Certificate are preferred and some Workshop training essential. Experience required is in layout drawings for processing equipment and design of process equipment. Starting salaries according to age and experience.—Written applications, giving full particulars of qualifications, training and experience to be addressed to Head Office, Staff Department (WF 50), Unilever House, Blackfriars, London, E.C.4. E8277 A

VACANCIES FOR TWO ENGINEERING CLERKS

Applications are invited for these two vacancies on the staff of the Chief Resident Engineer of several large pipelaying contracts in Lanarkshire.

The duties of the successful applicants would include the maintenance of filing systems, checking interim and final certificates of Contractors, copy typing and general office routine.

Previous experience of engineering works office routine would be advantageous.

It is anticipated that the appointments would be for about 18 months.

Salaries would be £600 per annum.

Written applications, with age and full particulars, should be addressed to the Chief Resident Engineer, Daer Water Scheme, c/o the Clerk to the Daer Water Board, P.O. Box No. 1, Lanarkshire House, 191, Ingram Street, Glasgow, C.1, not later than 20th January, 1960. Interviews by appointment will be held in Glasgow during the first week in February.

E8287 A

VACANCIES FOR TWO ASSISTANT RESIDENT ENGINEERS

Applications are invited from Civil Engineers to supervise pipe-laying contracts in Lanarkshire. The work would embrace setting-out, supervision of excavations in varying formations, including rock, the laying in trenches of large diameter steel pipes with "Viking Johnson" couplings, and other ancillary works, and the checking of contractors' interim certificates. It is anticipated that the appointments would be for about 18 months.

Applicants must have passed Parts (a) and (b) of the Examination of the Institution of Civil Engineers and preferably have had experience in similar works.

Salaries would be in the range £950–£1050 per annum, depending upon age and experience.

Written applications, with age and full particulars, should be sent to Messrs. Binnie, Deacon and Gourley, Consulting Civil Engineers, Artillery House, Artillery Row, Westminster, London, S.W.1, not later than 11th January, 1960.

E8294 A

VACANCIES FOR TEN INSPECTORS OF WORKS

Applications are invited from Inspectors of Works to supervise pipe-laying contracts in Lanarkshire.

The work would embrace supervision of excavations in varying formations, including rock, the laying in trenches of large diameter steel pipes with "VIKING JOHNSON" couplings, other ancillary works, the measurement of completed works and checking of contractors' interim certificates.

It is anticipated that the appointments would be for about 18 months' work. Salaries would be in the range £750–£850, depending upon age and experience.

Written applications, with age and full particulars, should be sent to Messrs. Binnie, Deacon and Gourley, Consulting Civil Engineers, Artillery House, Artillery Row, Westminster, London, S.W.1, not later than 11th January, 1960.

E8295 A

VACANCIES FOR FIVE RESIDENT ENGINEERS

Applications are invited from Civil Engineers to supervise pipe-laying contracts in Lanarkshire. The work would embrace setting-out, supervision of excavations in varying formations, including rock, the laying in trenches of large diameter steel pipes with "Viking Johnson" couplings and other ancillary works, and the checking of contractors' interim certificates. It is anticipated that the appointments would be for about 18 months.

Applicants must be Corporate Members of the Institution of Civil Engineers, preferably with experience in similar works.

Salaries would be in the range £1200–£1450 per annum, depending upon age and experience.

Written applications, with age and full particulars, should be sent to Messrs. Binnie, Deacon and Gourley, Consulting Civil Engineers, Artillery House, Artillery Row, Westminster, London, S.W.1, not later than 11th January, 1960.

E8296 A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, "The Engineer." A

SITUATIONS VACANT

FORD

invite applications for the post of

HYDRAULIC DESIGN ENGINEER

Applicants must

1. Be capable of calculations appropriate to high pressure hydraulic mechanisms.
2. Have had production drawing office and workshop experience.
3. Be qualified to H.N.C. standard or have an equivalent qualification.

Full details of age, experience, and qualifications to Mr. C. T. Perry, Training and Recruitment Department, Ford Motor Company Limited, Dagenham, Essex, quoting reference VHD.

E8253 A

BICC

RAILWAY ELECTRIFICATION

STRUCTURAL DESIGNERS

are required by

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY LTD.

for the Traction Contracts Department, Kirkby Industrial Estate, Nr. Liverpool, for work in connection with the design of structures and foundations for Railway Electrification schemes.

Applicants should be qualified to at least H.N.C. standard in structural engineering and have experience in the design of steel-framed portal structures and associated foundations.

These are senior and responsible appointments offering good salaries and first class conditions of employment, including Superannuation and Bonus schemes.

Applications should be addressed to :

Works Personnel Officer,
Ref. C.935,
B.I.C.C., Ltd.,
Prescot, Lancashire.

E8263 A

ICI

draughtsmen

To meet an expanding programme of development,

IMPERIAL CHEMICAL INDUSTRIES LIMITED
PLASTICS DIVISION

urgently need more Draughtsmen. In particular, men are required experienced in work associated with process plant, *e.g.* piping, heating and ventilating, drying, powder conveying and packing. Mechanical draughtsmen are also needed since the programme includes development work in novel processes which are essentially mechanical in nature. There are vacancies too for men with instrument and electrical design experience.

Good starting salaries will be paid and pension and profit sharing schemes are in operation. For married men temporary lodging allowances are available and assistance is given towards house purchase and removal expenses.

Apply briefly to the Staff Manager:

IMPERIAL CHEMICAL INDUSTRIES LIMITED
PLASTICS DIVISION
BLACK FAN ROAD, WELWYN GARDEN CITY, HERTS.

E8297 A

Classified Advts. continued on page 124

SITUATIONS VACANT

WELL ENGINEER

required by METROPOLITAN WATER BOARD. Salary scale : £1090–£1395 per annum. Commencing salary according to age, qualifications and experience. Pensionable post.

Applicants should be Corporate Members of the Institution of Civil Engineers and should have a knowledge of geology and experience in well and borehole sinking and in the supply of water from wells.

House available, if required, in good neighbourhood, at inclusive rental of about £143 per annum.

Successful candidate will be provided with car for use on official duties, or recommended for allowance for use of own vehicle.

Further particulars and form of application from the undersigned (reference E.).

S. D. ASKEW,
Clerk of the Board.
New River Head, Rosebery Avenue, E.C.1.

E8251 A

SITUATIONS VACANT

JOHNSON, MATTHEY & CO., LIMITED

DESIGN ENGINEER

Aged 23-33, with good drawing-office background, is required for the Chief Mechanical Engineer's office in Central London. A sound practical training and knowledge of engineering services is essential.

The work entails handling projects from the drawing-board through to construction and running in for production.

Conditions of service include free lunches and an annual bonus, also a contributory pension scheme. Salary according to age, qualifications and experience.

Write, giving full details of age, qualifications, experience, &c., to the Secretary, Johnson, Matthey & Co., Limited, 78, Hatton Garden, London, E.C.1.

E8030 A

SITUATIONS VACANT

REFRIGERATION ENGINEER

Unilever Limited require a Project Engineer with experience of refrigeration for their Food Research Department at Colworth House in North Bedfordshire. He will be the engineering member of one of several project teams concerned with the development of new processes for the expanding food interests of the Company. As some of these projects involve refrigeration, the applicant must have experience in refrigeration, a degree in engineering or A.M.I.Mech.E., and preferably be an Associate Member of the Institute of Refrigeration. An applicant should have served a full apprenticeship in refrigeration and have experience with refrigeration circuit design, including ammonia system. This is an ideal opportunity for an engineer to widen his experience through development work and through collaboration with the Unilever Food Companies. Prospects for advancement are good for a man with drive and initiative.

Starting salary would depend on experience and the Company operates a comprehensive superannuation scheme.

Applications should be sent to :—
The Staff Officer (Ref. FRR),
Unilever Limited,
Food Research Department,
Colworth House,
Sharnbrook,
Bedford.

E8239 A

SITUATIONS VACANT

NUCLEAR POWER PLANT OPERATION

SHIFT MANAGERS

are required by the United Kingdom Atomic Energy Authority, Production Group, at Windscale and Calder Works, Sellafield, Seascale, Cumberland. Applications are invited from Engineers and Physicists to fill vacancies on the advanced Gas Cooled Reactor project and at the Calder Hall Nuclear Power Station, to be responsible, on shift, for the safe and efficient operation of their station, including nuclear reactors, steam and electrical generating plant and associated experimental facilities.

Engineers must have served a recognised engineering apprenticeship and be Corporate Members of a Senior Engineering Institution or equivalent. Physicists should possess a good honours degree. Candidates should have had experience of plant operation, i.e. shift operation in a power station or work on a process plant or large-scale research facility. A course of training at a Reactor School and at an operating Nuclear Power Station will be provided.

Salary will be assessed within the scale £1370–£1825 p.a., according to qualifications and experience. Additional payments are made for regular shift work.

Contributory Superannuation Scheme. Staff Housing Scheme.

Send postcard for application form, quoting reference P.114/J1, to Recruitment Officer at above address.

E8240 A

ENGLISH ELECTRIC CO.

(WHETSTONE, Nr. LEICESTER)

GAS TURBINE DIVISION

Invite applications for appointments as

COMMISSIONING ENGINEERS

who would be required to accept responsibility for the initial operation of large industrial Gas Turbines and their erection at site.

Applicants, who should be of H.N.C. or Degree standard, must be prepared to work overseas and to accept considerable responsibility on the Company's behalf at site.

Appointments as Commissioning Engineers will be attractive to qualified engineers with some experience of the operation of high-speed rotating machinery in a responsible capacity. The work will involve some periods of overseas travel but it is envisaged that any difficulty this may cause will be offset by generous financial arrangements made during these periods.

You are invited to send personal details (which will be treated in strictest confidence) of qualifications, experience and salary to Dept. C.P.S., Marconi House, 336-7, Strand, London, W.C.2, quoting reference E1988A.

E8248 A

ENGINEERS WANTED

The United Cement Co., Baghdad, Iraq, is in need for the following ENGINEERS to work in its factory at the town of Samawah situated in the Southern part of Iraq. The machinery is made by F. L. Smidth & Co., of Denmark, and was installed only last year.

The Engineers Required and Qualifications

(1) CHIEF ENGINEER, should have a B.Sc. degree in Mechanical Engineering and should have had at least ten years' experience in the Cement Industry and at least 3 or 4 years of it as Chief Engineer.

(2) MECHANICAL MAINTENANCE ENGINEER, should have a B.Sc. degree in Mechanical Engineering with 4 or 5 years' experience as Mechanical Maintenance or W/shop. Engineer preferably in a Cement Factory or in any big plant of similar responsibility.

(3) ELECTRICAL MAINTENANCE ENGINEER should have a B.Sc. degree in Electrical Engineering with 4 or 5 years' experience as an Electrical Maintenance Engineer in preferably a Cement Factory or in any big similar plant with big responsibility.

(4) POWER HOUSE ENGINEER. To take charge of a diesel Power Station with four 1200 kW Mirrlees A.C.E.C. Engines. The Engineer should have a B.Sc. degree in Mechanical Engineering, and should have 4 or 5 years' experience supervising power stations of similar capacity and design.

---

(1) Accommodation. European type furnished living quarters are available free of charge.

(2) Pay is according to qualification.

E2656 A

Vacancies with opportunities

The following vacancies exist within a large organisation in the North West.

1. LAYOUT DRAUGHTSMAN

capable of creating shop floor layouts for the flow-line production of small components and assemblies.

2. PROGRESS SUPERVISOR

having experience of servicing flow Production/Assembly lines of light electrical components.

3. SENIOR STOREKEEPER

accustomed to working in association with continuous line production systems.

4. ELECTRICAL/ELECTRONIC INSPECTION FOREMAN

to be concerned with the creation and operation of Inspection procedures covering flow production.

5. SUPERVISOR

with experience of flow-line assembly in the manufacture of high precision electro-mechanical equipment.

The above positions call for initiative, originality of thought and enthusiasm in addition to experience.

Applications will be treated in confidence and should contain full details of age, qualifications and experience. They should be addressed to BOX No. E8246, *" The Engineer."*

A

ENGINEER

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE

To work as a member of a team engaged in the engineering and development of a wide range of electronic apparatus. This involves the interpretation of laboratory data, also the preparation of prototype technical and manufacturing information and test specifications. This post carries personal responsibility for the accuracy and reliability of such work and at times involves development of the solution of specialised problems. It may occasionally be necessary to carry out technical control of a contractors' work.

A.M.I.E.E. or equivalent qualification is required, with considerable experience of the engineering and development of complicated electronic instruments, including high-speed pulse equipment, wide band pulse amplifiers, control equipment, &c., and familiarity with R.C.S.C. Specification Lists, type approval procedure, &c. Experience of technical control of a model shop and design experience is desirable.

SALARY :—£845 (at age 25)–£1150 (at age 34 or over)–£1315.

Contributory Superannuation Scheme. A house, or substantial assistance with house purchase, will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the Senior Recruitment Officer at above address. Please quote ref. 2475/25.

E8243 A

SITUATIONS VACANT

WEATHERLEY OILGEAR LIMITED

TO SERVE THE MORE ADVANCED FIELD OF HYDRAULICS

REQUIRED: SENIOR TECHNICAL SALES ENGINEERS

to operate as district representatives for London and South—Midlands—Northern England—Scotland. Applications are invited from those already residing centrally in these areas.

Age Group : 35 to 45 years of age.

An informative period will be foreseen but qualifications should include a good practical as well as technical knowledge and experience of the modern version of Hydraulic and Processing Applications for industry at large.

Also required are four layout engineers, either experienced in Hydraulic Application or with good technical qualifications for training.

Applicants are asked to forward fullest information, including education, training and experience (present Salary Status will help) and sufficient detail to facilitate early arrangements for interview in London.

Address to : Personnel Manager, HYDRAULIC DIVISION, Weatherley Oilgear Limited, Biggleswade, Beds.

E8189 A

SITUATIONS VACANT

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

If you are an experienced **SCIENTIST** or **ENGINEER** and think that you may be interested in a **SENIOR POST** (salary from £3000 upwards) with the United Kingdom Atomic Energy Authority, you can learn more about the opportunities available, without committing yourself to making a formal application, by making use of the Authority's

CONSULTATION SERVICE

Arrangements can be made for an

Informal and confidential interview

by telephoning or writing to Mr. H. S. Hoff, Personnel Consultant, U.K.A.E.A., 11, Charles II Street, London, S.W.1. (Whitehall 6262.)

The more relevant detail about yourself that you can supply in advance—qualifications, experience, age, &c.—the better.

The interview will be entirely confidential. The Authority will take no further action unless you ask them to do so.

E8000 A

KELLOGG INTERNATIONAL CORPORATION

the leading contractors in petroleum refinery and chemical plant construction, invite applications for the following positions.

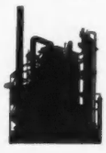
SENIOR ELECTRICAL DESIGNER

Applicants should preferably have H.N.C. or equivalent in electrical engineering, together with broad experience in the designing of power installation, lighting distribution, panel boards, industrial controls, etc., in petroleum, petrochemical or similar plants. Manufacturing experience would be an advantage. A good working knowledge of French is necessary.

ELECTRICAL DRAUGHTSMAN

Applicants should have O.N.C., with two years' experience of layout of power and lighting distribution in petroleum, petrochemical or similar plants.

Above average salaries, overtime worked when necessary with payment. Comprehensive personnel benefits include contributory pension scheme, excellent working conditions, luncheon vouchers, Social Club, etc.



Please write to the Personnel Manager,
KELLOGG INTERNATIONAL CORPORATION
KELLOGG HOUSE · 7-10, CHANDOS STREET · LONDON · W.1.
QUOTING REFERENCE 149/G

E8275 A

GENERAL WORKS MANAGER REQUIRED

by

Old-Established Precision Engineering Company, to control modern Works employing over 2000 on a range of medium sized precision products.

Applicants must have had a sound workshop training and be thoroughly familiar with the latest practice in precision machinery, assembly and allied processes.

Expert knowledge of production control and modern factory organisation procedures essential. Would be responsible for all aspects of factory administration, including labour relations.

Must be a good team leader, with initiative and drive.

Preference given to candidate with senior management experience in similar position.

Applicants who are not already in receipt of a salary of £3000 per year are unlikely to have the necessary qualifications.

Please reply in confidence to BOX E1019 L.P.E., Romano House, 399/401, Strand, London, W.C.2.

E8269 A

DEPUTY PRODUCTION ENGINEER

Required for a medium-sized company manufacturing specialised equipment for the vehicle and motor-car industries.

The Deputy Production Engineer will be responsible to the Production Engineer for the supervision of engineering staff covering process planning, work measurement, tool design and manufacture.

Candidates, who should have professional qualifications in production and mechanical engineering, must have extensive experience of modern machine tools, process planning, jig and tool design and work study in the light mass-production engineering field.

Experience in the design of special purpose transfer machines would be an advantage.

Age group : 30-45. Four-figure salary and non-contributory pension scheme. Please send full details of career in confidence, quoting reference LRM/PE.1, to CLAYTON DEWANDRE COMPANY, LIMITED, Titanic Works, Lincoln.

E8211 A

SENIOR DRAUGHTSMEN

experienced in bulk mechanical handling or foundry work. Superannuation Scheme. Five-day week. Apply to MARCO CONVEYOR & ENGINEERING COMPANY Ltd., Lynn Road, Leytonstone, London, E.11. LEY 2254.

E8169 A

MATERIALS HANDLING ENGINEER

Required for a medium-sized company manufacturing specialised equipment for the vehicle and motor-car industries. The Materials Handling Engineer will be responsible to the Production Engineer for materials handling and factory layout.

Essential qualifications :—

(*a*) Experience in the preparation of materials handling schemes, including palletisation and conveyorisation in current use in the light mass-production engineering industry.

(*b*) Sound knowledge of modern factory layout for batch and flow production in machine, assembly and plating shops.

(*c*) Knowledge of machine design, planning, work study and foundry practice would be an advantage.

Candidates should have professional qualifications in production or mechanical engineering.

Age group : 30 to 45. Four-figure salary and non-contributory pension scheme. Please send full details of career in confidence quoting reference LRM/PE.2, to CLAYTON DEWANDRE COMPANY LIMITED, Titanic Works, Lincoln.

E8212 A

SITUATIONS WANTED

AN EXPANDING BUSINESS ?

NEW CONTRACT now sought by young, qualified Engineer. ASSISTANT GENERAL MANAGER, TECHNICAL SALES MANAGER, or similar executive position. Management experience, administrative strength and knowledge of all aspects of industry. Ability backed by design, production, sales and commercial experience. If you are seeking to strengthen your management, write to BOX No. E2661, " The Engineer."

B

ENGINEER SEEKS CHANGE. Experience Medium Plant layout and services. Low Pressure Vessels with Cooling, Cold Stores, MS, ST. ST. and Copper Fabrication, Heat Recovery (Jet Condensers and Calorifiers), Powder Handling and Filling with Conveyor layouts and Auto Machines and Controls. Pumps and Circuits, Specifications and Installation. H.N.C. Seeks post with broad scope. Age 46. London and Kent.—BOX No. E2657, " The Engineer." B

WORKS MANAGER, A.M.I.Mech.E., experienced and competent engineer, production and construction, desires change. South preferred.—BOX No. E2655, " The Engineer." B

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

BUSINESS OPPORTUNITIES

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25-28, Buckingham Gate, S.W.1, or telephone VICtoria 6621 (12 lines). E155 O

PATENTS

THE PROPRIETOR of British Patent No. 756700, entitled " APPARATUS FOR GENERATING A MIST OR FOG OF LUBRICATING OIL," offers same for License or otherwise, to ensure practical working in Great Britain.—Enquiries to Singer, Stern and Carlberg, 14, E. Jackson Blvd., Chicago 4, Illinois, U.S.A. E8179 H

" TAKE-OFF MONITOR FOR AIRCRAFT." British Patent No. 755901. The Owners of this Patent will grant Licences or will sell the entire British Patent Rights.—Apply Bromhead & Co., Chartered Patent Agents, 19-23, Ludgate Hill, London, E.C.4. E8252 H

THE PROPRIETOR of British Patent No. 755082, entitled " SUBSURFACE WELL TOOLS," offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern & Carlberg, 14, E. Jackson Boulevard, Chicago 4, Illinois, U.S.A. E8264 H

THE PROPRIETORS of British Patent No. 761,720, dated the 25th August, 1954, relating to " PISTON RINGS FOR INTERNAL COMBUSTION ENGINES, COMPRESSORS OR OTHER RECIPROCATING ENGINES," are desirous to enter into an arrangement by way of a Licence or other reasonable terms for the purpose of exploiting the Patent and ensuring its practical working in Great Britain.—All enquiries to be addressed to : HERON ROGERS & CO., Bridge House, 181, Queen Victoria Street, London, E.C.4. E8283 H

Classified Advts. continued on page 126

FOR HIRE

LATTICE STEEL ERECTION MASTS (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. E103 K

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REQUIRED back numbers of "The Engineer" for July 5th, July 12th and November 1st, 1957. Reasonable prices annd expenses paid.—Write in first instance to The Hunslet Engine Co., Ltd., 125, Jack Lane, Leeds, 10. E173 I

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E R

By Order of the Secretary of State for War

GOVERNMENT SURPLUS STORES

SALES BY AUCTION

		Main Location	*Auctioneers*
January 4-8	**Machine tools and miscellaneous stores,** including :—	M.O.A. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
	S.S. and S.C. Lathes; capstans and turret lathes; hiloplane horizontal and openside planing machines; horizontal, drilling and boring machines; surface, camshaft and internal grinders; gear hobbing, milling, slotting, shaping, engraving, radial and tapping machines; automatic bevel gear generator; punching, shearing and angle cropping machines; plate bending rolls; plate straightening, plate folding and bending machines; 75-ton chain testing machine; hacksawing machines; guillotines; welders; hydraulic presses; woodworking machinery; laundry plant; fork lift trucks; diesel and petrol electric generating and charging sets; air compressors; pumps; tubular steel scaffolding; gravity roller conveyor; radio and radar stores and equipment; binoculars; prismatic compasses; waterproof covers; groundsheets; blankets; boots; kitbags; old webbing; hand tools; etc. The above includes the clearance of stores from H.M. Dockyard, Sheerness.		
January 15	**Miscellaneous stores.**	Returned Stores Group, Reed Hall, Colchester, Essex.	FENN, WRIGHT & CO. (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
February 2	**Miscellaneous stores.**	M.O.A. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)

Applications for catalogues, available 14 days prior to date of sale, should be made *only* to the auctioneers shown above (price of catalogue 1s. 0d. P.O. only).

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Tenders must be submitted by 11th January, 1960.
Applications for Tender Forms should be made to the War Office, Directorate of Disposals, First Avenue House, High Holborn, London, W.C.1.

E118 J

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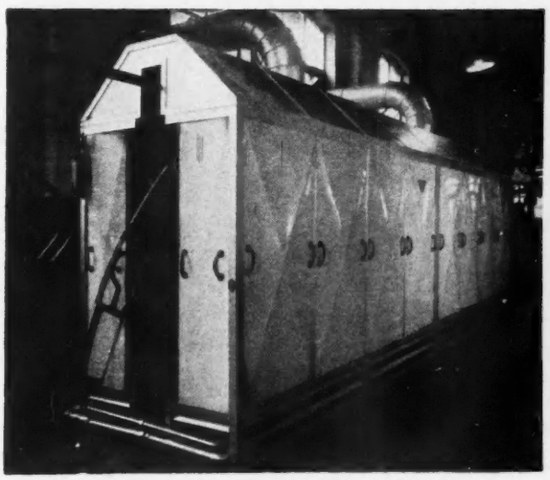

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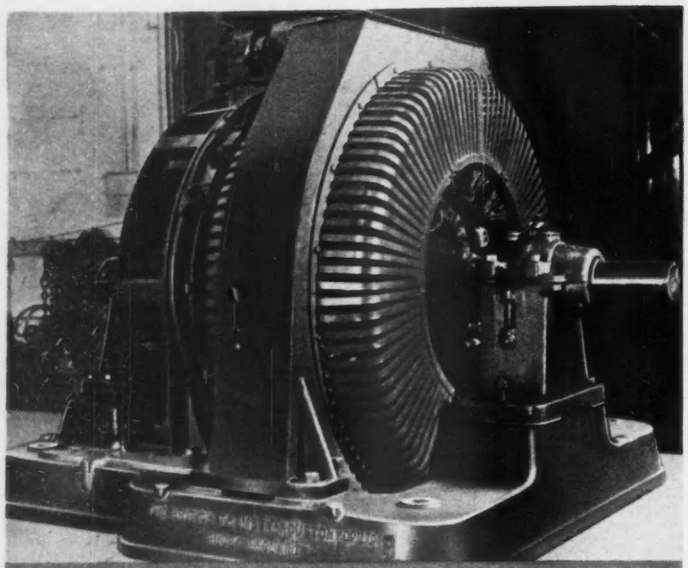

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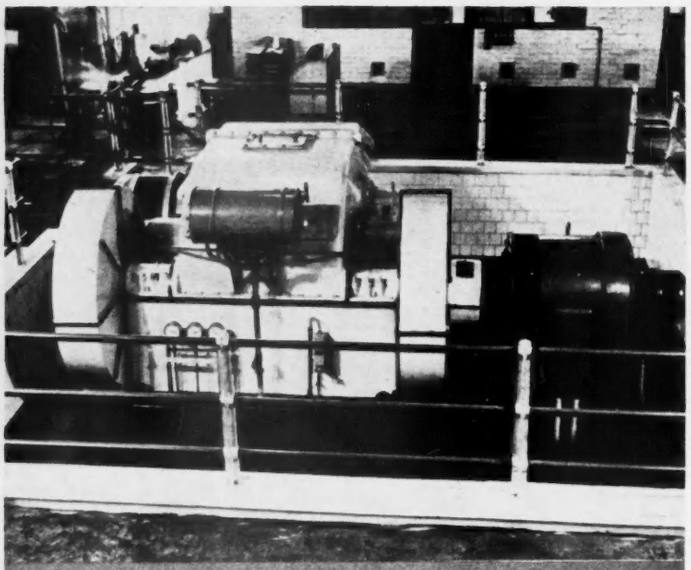

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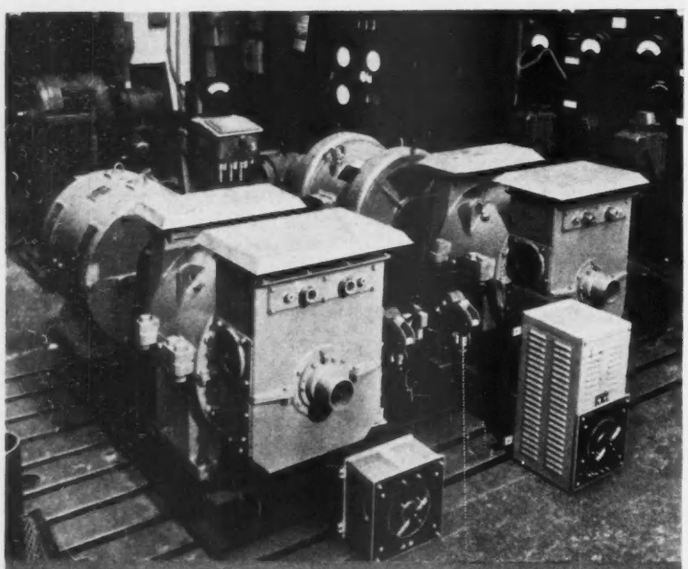

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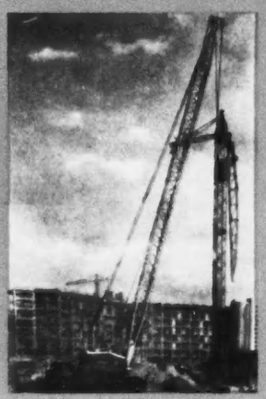
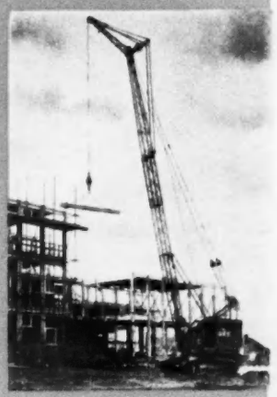
Smith Excavators digging and loading sand and gravel for new motorways programme.



Smith M.E.I. truck crane using 100 foot boom to dismantle a tower crane.

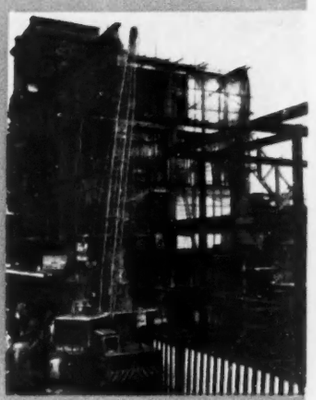


Smith crawler crane positioning concrete units during the erection of a new school.

Smith diesel crane handling scrap in a leading iron and steel scrap merchants' yard in Manchester.

Smith level luffing dockside crane employed at the Dagenham works of the Ford Motor Company.

Smith 21 dragline feeding material to a John Laing batching plant for the M1 Motorway.



Smith M.E.H. truck crane positioning steel units on extensions to a large store in Dublin.

Smith 25-ton capacity diesel-electric crane supplied to a prominent engineering company.

Smith Excavators, working as a team, show the effectiveness of strip-mining methods developed by Northern Strip Mining Ltd.

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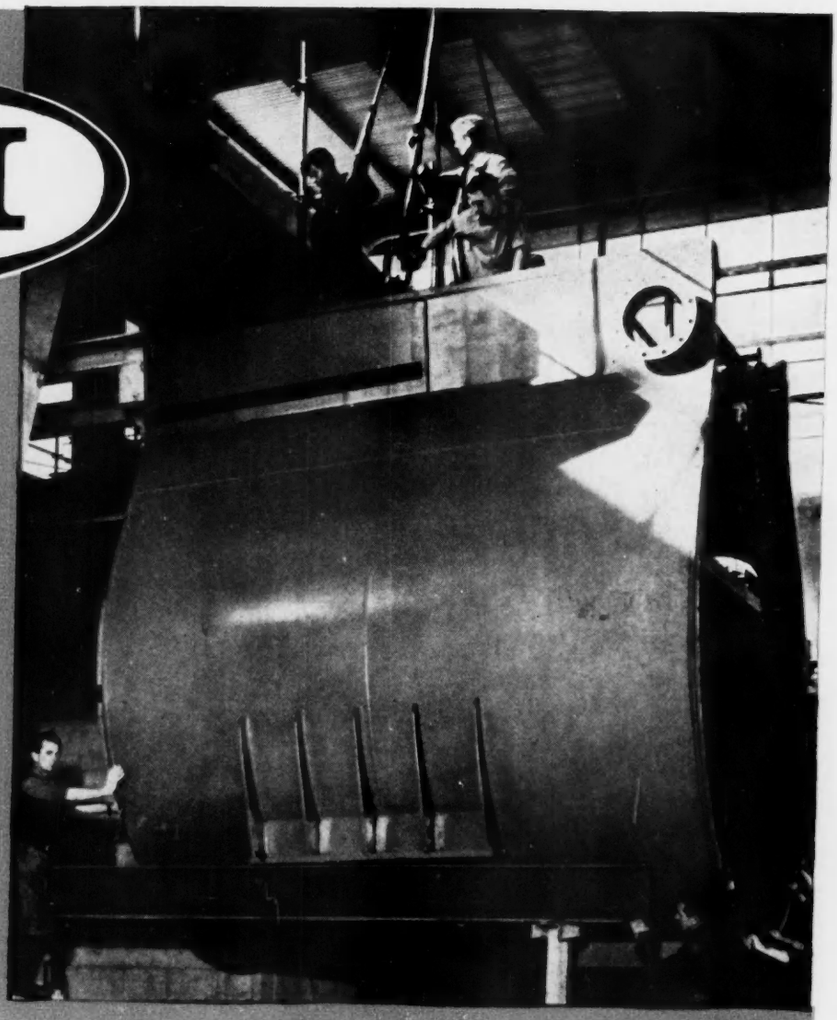
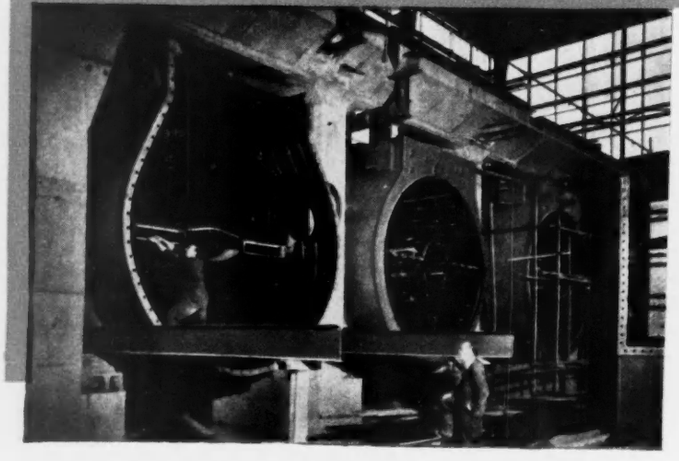


One unit of a three-shell surface condenser being placed in position at Berkeley, the commercial nuclear power station now under construction in Gloucestershire by the A.E.I.—John Thompson Nuclear Energy Company.

FOR BERKELEY NUCLEAR POWER STATION



A general view of three condenser shells in position at Berkeley.

The entire turbine-house heat exchange equipment for the new power station at Berkeley is being supplied by the A.E.I. Turbine-Generator Division, and manufactured at their factory at Germiston Glasgow.

Four three-shell main condensers — one for each of the four 83 MW mixed-pressure steam turbine-generators also being supplied by A.E.I.

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